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Energy Consumption and Economic Growth in Pakistan: A Sectoral Analysis

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Abstract

The study aimed at investigating the relationship between energy consumption at aggregate and disaggregate levels i.e., oil, coal, gas and electricity in different sectors (commercial, agriculture, industry, power and transport) of the economy with the economic growth in Pakistan. Annual time series data for the time period ranging from 1972 to 2014 has been used in this study. Autoregressive distributed lag bound testing approach for cointegration and to find the relationship between variables Granger causality test is applied. The results of the study showed that there exists a long run relationship between the dependent variable (economic growth) and independent variables (aggregate and disaggregate oil, coal, gas and electricity consumption in different sectors). It is also found that there exists a Neutrality Hypothesis between aggregate and disaggregate oil consumption and Conservation Hypothesis is found in aggregate and disaggregate coal, gas and electricity consumption. This study recommends that government should increase job opportunities in industrial sector where oil is used for production, shift their burden to cheap available resource from coal and transfer the units of electricity to industrial sector so that economic growth of Pakistan can be enhanced.

Keywords: Energy Consumption, Economic Growth, Disaggregate, ARDL, Pakistan.

JEL: C32, O13, Q43

1. Introduction

Energy has been considered as a key factor of production in addition of capital, labor and technology. It has a major role to play in the economic growth of any country. Efficient use of energy may lead to higher economic growth and reduction in it can decrease the economic growth of country. Similarly, economic growth may also affect the consumption of energy. In previous literature, there are mixed results about the direction of causality between the two variables. If there is unidirectional causality from energy consumption to economic growth it means that country is energy dependent and only increase in energy can boost the economic growth and called as Growth Hypothesis (Saatci and Dumrul, 2013). If there is a bidirectional causality between them then it implies that both variables can affect each other and can serve as complements and known as Feedback Hypothesis (Apergis and Payne, 2009). If there is no causality exists between them this means that economic growth of the country does not affected by energy consumption and termed as Neutrality Hypothesis (Cheng, 1999). If causality runs from economic growth to energy consumption it means that energy consumption can increase in response of increase in economic growth and named as Conservation Hypothesis (Lise and Montfort, 2007).

Since 2006, Pakistan is facing energy crisis. The major reasons are inefficiency of capacity addition, limited research resources, ineffective use of hydro and coal, inefficient consumption of energy and renewable resources. This results in demand supply gap which leads to load-shedding of electricity and gas. On average, the shortfall of electricity supply was around 5,000 Megawatt (MW), while it increased up to 7,000 MW in July 2014. Pakistan's current energy supplies are high towards other non-renewable sources like oil and gas instead of indigenous hydro and coal. Out of 67 million tonnes of oil equivalent (MTOE) of total primary energy mix for 2013-14, 46.4 per cent share is of natural gas, 35 per cent oil, 11.4 per cent hydro, 5.4 per cent coal and two per cent nuclear, including imported energy (Pakistan Economic Survey 2014-15).

There has been an extensive literature on the relationship between energy consumption and economic growth. The literature on the energy consumption and economic growth can be divided into three streams and these are further divided into three strands (unidirectional causality, bidirectional causality and combination of unidirectional, bidirectional and no causality). The first stream shows significant relationship between energy consumption and economic growth.

The main findings in the literature is that there is a unidirectional relationship between energy consumption and economic growth (Bartleet and Gounder, 2010; Saatci and Dumrul, 2013; Siddiqui, 2004). Few studies in the literature shows the bidirectional relationship between energy consumption and economic growth (Narayan and Smyth, 2008; Apergis and Payne, 2009; Hou, 2009). While some shows the mixed results that there is both unidirectional and bidirectional relationship between the two variables (Wolde and Rufael, 2009; Asafu and Adjaye, 2000; Oh and Lee, 2004). The second stream argues about the relationship between disaggregate energy consumption and economic growth. Researchers disaggregate the energy consumption into coal, electricity, oil and gas and revealed the unidirectional relationship (Halicioglu, 2007; Pempetzoglu, 2014; Khan and Ahmad, 2008), as well as bidirectional relationship between these variables (Apergis and Payne, 2011; Zachariadis and Pashourtidou, 2007; Lang et al., 2010). There are studies that shows both bidirectional and unidirectional relationships (Abid and Mraihi, 2015; Furuoka, 2015) and the combination of unidirectional, bidirectional and no causality (Wolde and Rufael, 2006; Yoo and Kwak, 2010; Chaudhry et al., 2012). The third stream found the linear and non-linear relationship of disaggregate energy consumption and economic growth. Studies exhibit the unidirectional relationship between these variables (Raheem and Yusuf, 2015; Amiri and Zibaei, 2012; Lee and Chang, 2005) and combination of both unidirectional and bidirectional relationship between disaggregate energy consumption and economic growth (Wei et al., 2008).

In sum, literature provides mixed results for the direction of the causality between energy consumption and economic growth, disaggregate energy consumption in different sectors and linear and non-linear relationship between these variables. But, there is limited work on the relationship between economic growth and energy consumption in Pakistan. The study aims at fulfilling this gap by analyzing the relationship between aggregate and disaggregate energy consumption in different sectors i.e. commercial, agriculture, industry, power and transport with economic growth in Pakistan.

The purpose of this study is to analyze the relationship between energy consumption at both aggregate and disaggregate levels in different sectors i.e. commercial, agriculture, industry, power and transport with economic growth in Pakistan over the time period of 1972 to 2014. Following are the specific objectives of the study: to analyze the relationship between oil consumption and economic growth, to analyze the relationship between coal consumption and economic growth, to analyze the relationship between gas consumption and economic growth, and to analyze the relationship between electricity consumption and economic growth. This study will prove to be a significant contribution to the existing literature by analyzing the relationship between energy consumption in different sectors with economic growth in Pakistan. It will help the policy makers to make decisions regarding which energy consumption affects the economic growth so that it can be increased by taking specific measures.

The theoretical framework of the study is on the basis of neo-classical growth model developed by Solow (1956). The study follows Abid and Mraihi (2015), Gbadebo et al. (2009), Zachariadis and Pashourtidou (2007), Pempetzoglou (2014), Halicioglu (2007) and Lang et al. (2010) to estimate the disaggregate energy consumption and their relationship with economic growth. This study has used Augmented Dickey Fuller (ADF) and Phillips-Perron (PP) unit root tests to check the order of integration of the time series data. After confirming the order of the integration, ARDL bound testing approach is used to find the long relationship between variables. Granger causality test is applied to analyze the short run and long run causality between the variables. In this study time series data on Pakistan at an annual frequency has been used.

The structure of the study is as follows. Section 2 discussed the literature review. Section 3 described the model, methodology and data of this study. The empirical analysis is presented in section 4. Section 5 covers the conclusion and policy recommendations.

2. Literature Review

The relationship of aggregate and disaggregate energy consumption with economic growth has received much consideration by policy makers that how much economic growth is affected by the different sources of energy consumption. There is a comprehensive literature that discusses the correlation between aggregate and disaggregate energy consumption and economic growth. The literature in this section is divided into three subsections.

2.1. Literature on Energy Consumption and Economic Growth

Cheng (1999) examined the causality between energy consumption, capital, labor and economic growth in India. He used annual data of India from 1952 to 1995 and Johansen Cointegration and Hsiao’s Granger Causality test were adopted for estimation. The study detected that no causal relationship exists between energy consumption and economic growth. It is also obtained that unidirectional causal relation move from economic growth to energy consumption and in the short run it move towards economic growth from capital. The conclusion of this study demonstrates that the key ingredient of economic development in India is capital accumulation. Bartleet & Gounder (2010) analyzed the energy usage and economic growth nexus in New Zealand. They have used annual time series data for the time span ranging from 1960 to 2004 and applied autoregressive distributed lag, Granger-causality trivariate and multivariate estimates for estimation. The Granger-causality was found from real GDP to energy consumption. The conclusion implied that economic and environmental policy objectives may be simultaneously achievable and the breadth of policy options may not be limited to energy instruments. Narayan & Smyth (2008) aimed at investigating the link of energy consumption with real GDP in G7 countries. They used annual data for the time period 1972 to 2002 and panel cointegration, OLS estimator, FMOLS estimator and dynamic OLS (DOLS) estimator were employed in this study. The findings of the study showed that there exists bidirectional causality between real GDP, capital formation and energy consumption in the selected economies.

Wolde & Rufael (2009) re-considering the causal connection between energy consumption and economic growth for seventeen African countries. This study used annual data for the period ranging from 1971 to 2004 and Granger causality and Variance decomposition analysis were applied for estimation. The results showed that there is unidirectional causality runs from either energy consumption to economic growth or from economic growth to energy consumption in few countries of the sample. In few countries, bidirectional causality was found and in one county no causality was found. The current energy infrastructure in almost all African countries is insufficient to maintain economic development so that economic growth can be increased. Apergis & Payne (2009) analyzed the correlation of energy consumption with economic growth in 11 countries of the Commonwealth of Independent States. Authors used annual data from 1991 to 2005 and fully modified OLS and panel vector error correction were employed for estimation. The results supported the feedback hypothesis which asserts that energy policies improve the efficiency in the production and consumption of energy might have no effect on economic growth, but may also enhance environmental quality.

Asafu & Adjaye (2000) aimed to find the association of energy consumption with income in India, Indonesia, the Philippines and Thailand. The time period of India and Indonesia ranges from 1973 to 1995, while for Thailand and the Philippines the time span ranging from 1971 to

1995. The study employed Johansen multivariate maximum likelihood and Granger causality tests for estimation. The study concluded that there is unidirectional causal link moving towards income from energy in India and Indonesia, while bidirectional causal relation between energy and income in Thailand and the Philippines. Only in Indonesia, there are rather extreme policies for energy conservation without effecting economic growth. Hou (2009) investigated the causal link between energy consumption and economic growth in China. Annual time series data ranging from 1953 to 2006 and Johansen test, Hsiao Granger and Hsiao on ECM were used in this study. The study found the bidirectional relation between economic growth and energy consumption. Sensitive and influential factors of energy industry are both high, so the economic growth is promoted by the development of energy industry which also expedite the growth of other industry. Saatci & Dumrul (2013) re-considered the causal association between energy consumption and economic growth with structural breaks in Turkey. Annual data of Turkey was taken from 1960 to 2008 and structural break cointegration test proposed by Kejriwal was used in this study. The results showed the positive link between energy consumption and economic growth varying with regime shift. In general, over the years the relationship between oil consumption and economic growth increased, meaning the energy dependence of the economy has increased.

Oh & Lee (2004) analyzed the causal relationship by applying a multivariate model between energy consumption and economic growth. Study used yearly time series data of Korea from 1970 to 1999 and cointegration and Granger causality tests and log mean Divisia index method were adopted for estimation. The results showed that in long run, energy and GDP have bidirectional causality while in the short run unidirectional causality moving towards GDP from energy. Siddiqui (2004) examined the issue of causality between economic growth and energy use for Pakistan. Author used time series data from 1970 to 2003 and causality tests and autoregressive distributed lag model for estimating the relationship. The results showed a unidirectional relationship between energy use and economic growth. From the analysis, it was concluded that energy is an important element of economic growth.

2.2. Literature on Disaggregate Energy Consumption and Economic Growth

Apergis and Payne (2011) investigated the relationship between renewable and non-renewable energy consumption and economic growth for developed and developing countries. They used yearly data for the period from 1990 to 2007 and fully modified ordinary least squares (FMOLS) technique for heterogeneous cointegrated panels were employed. The study found that both in the short and long run**,** there is a bidirectional causality between renewable and non-renewable energy consumption and economic growth. Abid and Mraihi (2014) analyzed the causality between energy consumption and gross domestic product in Tunisia at both aggregated and disaggregated levels. Authors used time series from 1980 to 2012 and Johansen-Moscow-Nielsen cointegration test and VECM was applied for investigating short and long run causality. The study showed that there is a unidirectional causality running from disaggregated energy consumption to economic growth, but bidirectional causality between economic growth and aggregated energy consumption. Therefore, in order to preserve the rhythm of economic development, the Tunisian government must invest in promoting energy infrastructure.

Wolde and Rufael (2006) examined the long run and causal relationship between electricity consumption and economic growth for 17 African countries. This study used annual data from 1971 to 2001 and employed Cointegration test and Toda–Yamamoto approach of Granger causality test. The results of the study showed that in 6 countries, there exist a positive causality moving towards electricity consumption per capita from real GDP per capita, an opposite causality in 3 countries, bidirectional causality in the remaining 3 countries while in remaining 9 countries there exists a long run relationship. Yoo and Kwak (2010) attempted to inspect the cause and effect relationship between electricity consumption and economic growth in seven South American countries. Authors used panel data of annual frequency from 1975 to 2006 and Cointegration and Error Correction Modelling were applied for estimation. The study concluded that in 5 countries the causality is moving from electricity consumption to economic growth, bidirectional causality in 1 county and no causal relation in 1 country. A high level of electricity consumption results in high level of real GDP. This implies that an economic growth may restrain in those countries due to the shortage in the infrastructure for electricity consumption.

Zachariadis and Pashourtidou (2007) examined the electricity use in the residential and the services sectors of Cyprus. The study used annual data from 1960 to 2004 and vector error correction model (VECM) and Granger Causality tests were adopted for estimation. The study found the bidirectional causality between residential electricity consumption and private income. The conclusion is that commercial sector is less prone to changes in income, prices and the weather, and it return to equilibrium much faster than the household sector. Halicioglu (2007) analyzed the income and price elasticities of the household energy consumption both in the short-run and long-run in Turkey. The study utilized annual data from 1968 to 2005 and autoregressive distributed lag and error correction model tests in this study. The results showed that in the long run, causality is moving to residential energy from income, price and urbanization. Maria Pempetzoglou (2014) examined the potential linear and nonlinear causality between electricity consumption and economic growth in Turkey. Annual time series data from 1945 to 2006 had been used and standard linear granger causality test and the nonparametric Diks and Panchenko causality test for estimating the cause and effect relationship. The study detected a unidirectional nonlinear and linear causality at the aggregate and disaggregated level between income and electricity consumption. In Turkey, important aspect of economic growth is allocated to electricity consumption but the magnitude of its effect remains unpredictable.

Lang et al. (2010) investigated the linear and nonlinear causality between the total electricity consumption and real gross domestic production in Taiwan. The study used quarterly data from 1982 to 2008 and Granger causality and BDS tests were employed. The results of the linear and non-linear causality revealed that the causality exists between total electricity consumption and real gross domestic production. Fumitaka Furuoka (2015) examined long run cointegration causal linkages between electricity consumption and economic development in 12 Asian countries. Author used annual data from 1971 to 2011 and Panel Analysis of Nonstationarity in Idiosyncratic and Common Components (PANIC) was employed in this study. The study concluded that there exists causality moving from electricity consumption to economic development in South Asia while there was a reverse causality from economic development to electricity consumption in East Asia.

Khan & Ahmad (2008) analyzed the sectoral relationship i.e., petroleum, gas, electricity and coal consumption with real GDP and domestic price level for Pakistan. The study was based on annual data from 1972 to 2007 and they employed Johansen and Juselius multivariate cointegration and short run vector autoregressive method for estimation. The results suggested that there is unidirectional causality from real income and domestic price level to coal demand and no causality between coal consumption, domestic price level and real GDP in the short-run. Chaudhry et al. (2012) investigated the link between energy consumption and economic growth in Pakistan. The study utilized annual data from 1972 to 2012 and cointegration and Granger Causality tests were employed. The results of the study indicated that unidirectional causality moving towards GDP from electricity consumption, oil consumption and gas consumption while bidirectional causality between GDP and coal consumption and no causality was found between gas and electricity, gas and oil and coal and oil.

2.3. Literature on Disaggregate Energy Consumption and Economic Growth-Linear and Nonlinear Relationship

Wei et al. (2008) investigated the causality between energy consumption and economic growth in Asian newly industrialized countries and in U.S. The study involved annual data from 1954 to 2006 and Granger Causality tests to estimate linear models while BDS test and non-linear Granger Causality test to estimate non-linear models were employed. The study found that for linear models there exists a unidirectional causality in 2 countries as well as bidirectional causal linkage in 2 countries and no causality was found in 3 countries. And for non-linear models, bidirectional causal relation were found in 5 countries while unidirectional relationship in 2 countries. To sustain economic growth, countries should actively seek other energy-related strategies and develop alternative energy resources. Raheem and Yusuf (2015) empirically analyze both linear and nonlinear models on the relationship of energy consumption with economic growth in fifteen African countries. Authors conducted time series analysis from 1980 to 2010 and for linear relationship OLS was employed and for non-linear relationship TAR model were adopted. The study detected the inverted U shape for 5 countries, the energy consumption reduces growth in 2 countries, high regime energy enhances growth in 3 countries while no causal relationship found in 2 countries. The high energy consumption in Benin, Cote d'Ivoire, Egypt, Togo and Tunisia lead to a negative externality.

Amiri and Zibaei (2012) analyzed the linear and nonlinear Granger causality between energy consumption and economic growth in France. Authors used annual data from 1960 to 2005 and employed granger causality and Geostatistical analysis (kiriging and IDW) for the estimation. The study depicted that there exists a unidirectional causality from energy consumption to economic growth in both linear and non-linear models. Lee and Chang (2007) investigated the linear and nonlinear impact of energy consumption on economic growth in Taiwan. Yearly data had been used from 1955 to 2003 and authors adopted OLS, Ramsey RESET test for estimating the linear and nonlinear effects. The study concluded that association between energy consumption and real GDP growth takes an inverse U-shape in Taiwan. Changes are caused by deviations in energy consumption in the link between energy consumption and economic growth.

The relationship between energy consumption and economic growth has increased significance in past few years in all over the world. Their relationship also has been the point of attention for the policy makers. An inclusive literature has discussed the relationship between both aggregate and disaggregate energy consumption and economic growth in different parts of the world. But there are few studies which have studied the relationship of disaggregate energy consumption on the basis of different sectors of the economy i.e. commercial, agriculture, industrial, transport, fertilizer, etc. Hence, this study explored that part of study which will contribute to the existing literature.

3. Model, Methodology and Data

3.1 Model

Neo-classical growth model developed by Solow (1956) is linked to economic growth. Energy does not include as factor of production in the neo-classical growth models, but in last few decades its importance has grown. Economic growth models are built on five variables such as output, capital, labor, energy, and technological progress (Yuan et al. 2008). The aim of the study is to investigate the relationship between disaggregate energy consumption and economic growth in Pakistan. So to examine the relationship this study uses Cobb-Douglas production function as under:

$$\boldsymbol{Y_t = AK_t^{\alpha} L_t^{\beta} E_t^{\delta}} \quad \textbf{(1)}$$

Where, Y_t is economic growth, A is technology, K_t is capital, L_t is labor force, E_t is energy, $\alpha, \beta\ and\ \delta$ are the elasticities of capital, labor and energy respectively.

Following Abid and Mraihi (2015), Gbadebo et al. (2009), Zachariadis and Pashourtidou (2007), Pempetzoglou (2014), Halicioglu (2007) and Lang et al. (2010), this study disaggregate the energy into oil (OC), coal (CC), gas (GC) and electricity (EC) as:

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} OC_t^{\delta}} \quad \textbf{(2)}$$

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} CC_t^{\sigma}} \quad \textbf{(3)}$$

$$Y_t = A\,K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} GC_t^{\theta} \quad (4)$$

$$Y_t = A\,K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} EC_t^{\gamma} \quad (5)$$

3.2. Methodology

3.2.1. Econometric Models

This study has four econometric models and each model is further subdivided into two models (aggregate and disaggregate consumption). The first model is established to estimate the oil consumption and its relationship with economic growth. This model is further divided into aggregate and disaggregate oil consumption. In aggregate oil consumption model, dependent variables is economic growth while independent variables are capital stock, labor force, human capital and total oil consumption and in the disaggregate model independent variables are capital stock, labor force, human capital, oil consumption in industry, agriculture, transport and power sectors. The second model is constructed to evaluate the association between coal consumption and output. In the aggregate coal consumption, economic growth is dependent variable while capital stock, labor force, human capital and total coal consumption and in the disaggregate model economic growth is regressed on coal consumption in power and brick kilns sectors in addition to capital stock, labor and human capital. Similarly, econometric model for gas consumption are constructed. In the aggregate gas consumption, dependent variable is economic growth while capital stock, labor force, human capital and aggregate gas consumption are taken as regressors. In the disaggregate gas consumption, economic growth is exogenous variable and capital stock, labor force, human capital, and gas consumption in commercial, cement, fertilizer and power sector are endogenous variables. The last model is built to explore the connection between electricity consumption and economic growth. Like all other models, dependent variable is same while capital stock, labor force, human capital and aggregate gas consumption are used as an endogenous variables whereas, in the disaggregate gas consumption independent variables are capital stock, labor force, human capital and electricity consumption in commercial, agriculture and industrial sectors and economic growth is again used as dependent variable. This study used autoregressive distributed lag model (ARDL) for cointegration and granger causality for short run and long run causality estimation techniques as methodology.

3.2.1.1. Model for Oil

This study scrutinizes the relationship between oil usage in different sectors of the economy and the economic growth by using the following econometric models for oil consumption:

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} OC_t^{\delta}} \quad \textbf{(3)}$$

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi}\; IOC_t^{\delta_1} AOC_t^{\delta_2} TOC_t^{\delta_3} POC_t^{\delta_4}} \quad \textbf{(3a)}$$

By taking 'ln' of the above equations:

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \delta \ln OC_t + \varepsilon_t} \quad \textbf{(3b)}$$

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \delta_1 \ln IOC_t + \delta_2 \ln AOC_t}$$

$$\boldsymbol{+\delta_3 \ln TOC_t + \delta_4 \ln POC_t + \varepsilon_t} \quad \textbf{(3c)}$$

Where, Y_t is economic growth, K_t is capital, L_t is labor, MS_t is total enrollment at middle school used as a proxy for human capital, OC_t is total oil consumption, IOC_t is oil consumption in industrial sector, AOC_t is oil consumption in agriculture sector, TOC_t is oil consumption in transport sector, POC_t is the oil consumption in power sector, and ε_t is the error term.

3.2.1.2. Model for Coal

This study analyzes the correlation between coal depletion in different sectors and the economic growth with the help of the following models:

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} CC_t^{\sigma}} \quad \textbf{(4)}$$

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} PCC_t^{\sigma_1} BKCC_t^{\sigma_2}} \quad \textbf{(4a)}$$

The log form of the above equations are:

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \sigma \ln CC_t + \varepsilon_t} \quad \textbf{(4b)}$$

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \sigma_1 \ln PCC_t + \sigma_2 \ln BKCC_t}$$

$$\boldsymbol{+\varepsilon_t} \quad \textbf{(4c)}$$

Where, CC_t is total coal consumption, PCC_t is coal consumption in power sector, $BKCC_t$ is the coal consumption in brick kilns sector, and ε_t is the error term.

3.2.1.3. Model for Gas

The following econometric models will be used to estimate the relationship of aggregate and disaggregate gas consumption with economic growth:

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} GC_t^{\theta}} \quad \textbf{(5)}$$

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} CoGC_t^{\theta_1} CeGC_t^{\theta_2} FGC_t^{\theta_3} PGC_t^{\theta_4} IGC_t^{\theta_5}} \quad \textbf{(5a)}$$

By taking 'ln' of the above equations:

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \theta \ln GC_t + \varepsilon_t} \quad \textbf{(5b)}$$

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \theta_1 \ln CoGC_t + \theta_2 \ln CeGC_t}$$
$$\boldsymbol{+\theta_3 \ln FGC_t + \theta_4 \ln PGC_t + \theta_5 \ln IGC_t + \varepsilon_t} \quad \textbf{(5c)}$$

Where, GC_t is total gas consumption, $CoGC_t$ is gas consumption in commercial sector, $CeGC_t$ is gas consumption in cement sector, FGC_t is gas consumption in fertilizer sector, PGC_t is gas consumption in power sector, IGC_t is gas consumption in industrial sector, and ε_t is the error term.

3.2.1.4. Model for Electricity

The models to empirically analyze the linkage between electricity consumption and its consumption in different sectors with the economic growth in Pakistan are:

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} EC_t^{\gamma}} \quad \textbf{(6)}$$

$$\boldsymbol{Y_t = A\, K_t^{\alpha} L_t^{\beta} MS_t^{\varphi} CoEC_t^{\gamma_1} IEC_t^{\gamma_2} AEC_t^{\gamma_3}} \quad \textbf{(6a)}$$

The log form of the above equations are:

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \delta_4 \ln EC_t + \varepsilon_t} \quad \textbf{(6b)}$$

$$\boldsymbol{\ln Y_t = \ln A + \alpha \ln K_t + \beta \ln L_t + \varphi \ln MS_t + \gamma_2 \ln CoEC_t + \gamma_3 \ln IEC_t}$$
$$\boldsymbol{+\gamma_4 \ln AEC_t + \varepsilon_t} \quad \textbf{(6c)}$$

Where, EC_t is total electricity consumption, $CoEC_t$ is electricity consumption in commercial sector, IEC_t is electricity consumption in industrial sector, AEC_t is electricity consumption in agricultural sector, and ε_t is the error term.

3.2.2. Tests of Stationarity

The study conducts time series analysis in which the first and most important step is to check that the data series are stationary to avoid spurious regression and misleading results. The time series data is very sensitive to unit root test and if the data series seem to have unit root problem then it may lead to ambiguous results. In order to escape the problem of unit root, this study uses ADF (Augmented Dickey Fuller) and PP (Phillips-Perron) unit root tests. Dickey and Fuller (1979) presented the Dickey-Fuller unit root test in which they assume that the error term are uncorrelated. But in order to address the situation when error terms are correlated, Dickey and Fuller presented an Augmented Dickey-Fuller unit root test in which they improved the previous unit root test by adding the lags of the dependent variable on the right hand side. To get rid of the serial correlation problem, lags of the dependent variable are added on the right hand side in ADF unit root test. Phillips and Perron (1988) dealt with serial correlation problem by proposing nonparametric statistical methods without adding the lag of the dependent variable.

3.2.3. Autoregressive Distributed Lag Model (ARDL)

There are various techniques that were used directly to check the co-integration between the variables (Engle-Granger, 1987; Johansen & Juselius, 1990; Johansen, 1995) but it is essential for these techniques that the variable should be of same order. Moreover, if the data sample is small then these traditional cointegration techniques are not reliable. However, to avoid these problems, when the variables are mixture of I(0) and I(1) then there is another technique of cointegration introduced by Pesaran, Shin and Smith (2001) which is known as "Autoregressive Distributive Lag". There are two assumptions of ARDL bound testing approach to cointegration i.e. regressand should be of order I(1) and none of the variable is of order I(2). Since, ARDL bounds testing is applied on mixture of variables integrated of order I(0) and I(1). ARDL bounds testing approach is better than other techniques due to following reasons: firstly, this technique does not require pre testing of the variables i.e. regressors are purely I(0) or I(1) or mutually integrated. Second, ARDL bounds testing approach gives information of the structural breaks in the series. Third, Error Correction Model (ECM) is obtained from ARDL by a simple linear transformation and error correction term (ECT) integrate short run adjustments with long run, finally, it gives more accurate result than usual integration techniques because in the presence of mixture of I(0) and I(1) standard co-integration techniques yield unstable results.

Specification of ARDL model:

$$\Delta \ln Y = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta \ln Y_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \ln X_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta \ln Y_{t-1} + \sum_{i=1}^{p} \alpha_{4i} \Delta \ln Y_{t-1} + \varepsilon_t \quad (7)$$

This is the dynamic linear equilibrium model. Where, on the right hand side the terms with Δ shows the first difference of the lagged variables. α, β, and γ represent the short run dynamics and φ_1, φ_2, and φ_3 are long run coefficient which shows marginal change in dependent variable due to change in explanatory variables. In order to test the cointegration, the following null hypothesis is tested:

H_0: φ1 = φ2 = φ3 =0 (There is no co-integration)

H_1: φ1 ≠ φ2 ≠ φ3 ≠ 0

In ARDL bound test the value of F-statistics is compared with upper and lower bounds. If the value is greater than upper bound then it confirms the existence of co-integration among the variables by rejecting the null hypothesis and if the value of F-statistics fall below the lower bound then there is no co-integration but if the value falls between the upper and lower bound then the results are inconclusive.

3.2.4. Diagnostic Tests

The strength of the model is tested by conducting diagnostics tests. Breusch-Godfrey (1978) test is to check the residuals for serial correlation, Breusch-Pagan test for heteroscedasticity (1979), and Ramsey Reset Test (1969) for functional misspecification. Moreover, the stability of the parameters is tested by CUMSUM and CUSUMSQ test. The term serial correlation refers to a situation when two error terms are correlated. In the presence of serial correlation variance of residuals will be underestimated, R^2 will report high value but t-statistics and F-statistics will be invalid. Which means that in the presence of serial correlation t-statistics and F-statistics will cause misleading conclusion. Residuals are checked for serial correlation under the null hypothesis (i.e. no serial correlation).

The term Heteroscedasticity refers to the situation when variance of the error term does not remain constant in the model. In the presence of heteroscedasticity the parameters will not have minimum variance although they are unbiased and consistent. Breusch-Pagan-Godfrey test is used under the null hypothesis of no heteroscedasticity. If model is not correctly specified then there is model specification error. And when the model is not correctly specified then variance of error term will be incorrectly estimated. Moreover, hypothesis testing will provide misleading results and forecasted values will be incorrect in the presence of model specification error.

CUSUM and CUSUMSQ tests have been used to check the stability of the parameters. Pesaran and shin (2001) also followed this test to observe the stability of the parameters in their analysis. According to Pesaran and shin (2001), the coefficient of ECM should be empirically investigated under these stability tests. The parameters of ECM can be checked for stability under the null hypothesis (the regression equation is correctly specified). We can accept the null hypothesis if the stability test remains within 5 percent level of significance.

3.2.5. Error Correction Model

To estimate the short run dynamics, it is necessary to transform the ARDL model into Error Correction Representation. Error correction term (ECT) is the rate of adjustment which indicates that how quickly variables adjust towards equilibrium and its negative sign represents the convergence in the short run. This term should be negative and statistically significant to establish the long run relationship among the variables. The specification of the error correction model:

$$\Delta \ln Y = \alpha_0 + \sum_{i=1}^{m} \alpha_{1i} \Delta \ln Y_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \ln X_{t-i} + \sum_{i=1}^{p} \alpha_{3i} \Delta \ln Y_{t-1} + \sum_{i=1}^{p} \alpha_{4i} \Delta \ln Y_{t-1} + \lambda ECT_{t-1} + \varepsilon_t \tag{8}$$

3.2.6. Causality Test

The ARDL through bound test confirms the existence or absence of the long run relationship among the variables but it does not tell us the direction of causality that which variable causes the other. For this purpose, ECM and Granger causality are used to determine the direction of causality. The Granger theorem states if variables have order of integration one, then there will be Granger causality in at least one direction if they are cointegrated. Granger (1988) stated that within the framework of the ECM, causal relations among variables can be examined. The individual coefficients of the lagged terms captured the short run dynamics while the error correction term contains the information of long run causality. So, to examine the relationship between variables, the study used VAR framework as follows:

$$\boldsymbol{\Delta \ln Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta \ln Y_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \ln X_{t-i} + \varepsilon_t} \qquad \textbf{(9)}$$

$$\boldsymbol{\Delta \ln X_t = \alpha_0 + \sum_{i=1}^{p} \alpha_{1i} \Delta \ln X_{t-i} + \sum_{i=1}^{p} \alpha_{2i} \Delta \ln Y_{t-i} + \varepsilon_t} \qquad \textbf{(10)}$$

3.2.7. Construction of Real Capital Stock

The real capital stock is constructed by using gross fixed capital formation, average rate of depreciation is supposed to be 5% (Siddiqui, 2004). Real capital stock series is calculated by following formula:

$$\boldsymbol{K_t = (1 - \mu)\, K_{t-1} + I_t} \qquad \textbf{(A)}$$

Where, K_t is real capital stock in time t, μ is rate of depreciation, I_t is gross fixed capital formation in year t.

In equation (1) 'μ' is rate of depreciation and supposed to be constant. While, initial capital stock is calculated using following formula calculated by Schclarek (2004)

$$\boldsymbol{K_0 = [I_{t-1}/(\mu + AGI]} \qquad \textbf{(B)}$$

Where, I_{t-1} is Gross fixed capital formation in previous year t-1, AGI is average growth rate of I_t.

3.3. Data

The study uses annual time series data of Pakistan for the time period ranging from 1972 to 2014. Data of labor force is collected from Pakistan Economic Survey (various issues). Fixed capital formation is collected from Handbook of Statistics (2010) and Pakistan Economic Survey (various issues). Real GDP is collected from Pakistan Economic Survey (various issues). Total enrollment at middle stage of education used as a proxy for human capital is taken from Pakistan Economic Survey (various issues). The data of energy is divided into four nonrenewable consumption i.e. oil consumption, coal consumption, gas consumption and electricity consumption and these are taken from Pakistan Economic Survey (various issues). The detailed description of the variables are given in Appendix A.

4. Results

4.1. Unit Root Tests

Unit root tests are used to check the stationarity of the time series data. Augmented Dickey Fuller (1979) and Phillips-Perron (1988) unit root tests are applied to check the order of integration of the variables. The results of the unit root tests in table 4.1 shows that the dependent variable (economic growth) is I(1) while the explanatory variables (capital, labor, human capital, aggregate and disaggregate consumption of oil, coal, gas and electricity) are mixture of I(1) and I(0). Results of the ADF test have been verified by Phillips-Perron unit root test and are given in table 4.1.

4.2. Results for Model of Oil Consumption

4.2.1. Results for Model of Aggregate Oil Consumption

4.2.1.1. Long Run and Short Run Dynamics

The results of unit root tests verify that assumptions of the ARDL bound testing approach are not violated as the variables are combination of I(0) and I(1) and none of the variable is of order I(2). So these results lead us to autoregressive distributed lag to find whether the variables are cointegrated or not. ARDL bound test is conducted to test whether the variables are cointegrated or not. Table 4.2 reports the results of unrestricted ECM model. After applying bound test, F-statistics is compared with the upper bounds and lower bounds values as suggested by Pesaran et al. (2001). The value of F-statistics in table 4.3 falls above the upper bounds at 1% significance level, which means that null hypothesis of no cointegration is rejected. So, this shows an evidence of strong cointegration. Results of the bound test are reported in table 4.3.

Table 4.1 Results of ADF and PP Unit Root Tests

Variables	Augmented Dickey Fuller		Phillips-Perron		Order of Integration	
	At Level	At 1st difference	At Level	At 1st difference	ADF	PP
LnOC	-1.8950	2.9232**	-1.7775	5.7708***	I(1)	I(0)
LnICO	0.9524	-4.2074***	1.0391	-4.1940***	I(1)	I(1)
LnACO	-1.2650	-5.3709***	-1.2221	-5.3481***	I(1)	I(1)
LnTCO	-3.5806**	-	-4.4674***	-	I(0)	I(0)
LnPCO	0.8887	-4.4282***	1.2304	-4.4123***	I(1)	I(1)
LnCC	-3.7211**	-	-2.6173	-7.2655***	I(0)	I(1)
LnPCC	-0.0892	-10.6627***	-3.1769	-10.7777***	I(1)	I(1)
LnBKCC	0.9834	-7.3393***	-1.6181	-7.2841***	I(1)	I(1)
LnGC	-3.1409**	-	5.0839	-4.5658***	I(1)	I(1)
LnCoCG	-5.7084***	-	-4.4068***	-	I(0)	I(0)
LnCeCG	-1.8331	-4.6355***	-1.5893	-4.6358***	I(1)	I(1)
LnFCG	-2.2965	-8.1609***	2.7958	-7.9453***	I(1)	I(1)
LnPCG	-3.2457	-4.8902***	-1.5908	-4.8854***	I(1)	I(1)
LnICG	-2.4403	-2.1448**	-1.5601	-3.5043**	I(1)	I(1)
LnEC	-3.5163**	-	-2.9479**	-	I(0)	I(0)
LnCoCE	-1.7897	-6.9018***	-2.0276	-6.8823***	I(1)	I(1)
LnICE	2.4832	-3.5534***	-1.1920	-3.5613**	I(1)	I(1)
LnACE	-2.0194	-6.2375***	-2.3099	-6.2385***	I(1)	I(1)
LnLF	-1.8913	-5.9198***	-2.0126	-5.9201***	I(1)	I(1)
LnK	-11.9167***	-	-10.2456***	-	I(0)	I(0)
LnY	-2.4529	-4.6040***	-2.2257	-4.6670***	I(1)	I(1)
LnMS	5.7118	-6.1380***	5.7118	-6.1453***	I(1)	I(1)

*Note: ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.2: Unrestricted ECM Model Estimation

Variable	Coefficient
LnY(-1)	0.6709*** (0.0713)
LnK	0.1677*** (0.0221)
LnLF	-0.1260 (0.0986)
LnLF(-1)	0.3988*** (0.1348)
LnLF(-2)	-0.4258*** (0.1358)
LnLF(-3)	0.0431 (0.1306)
LnLF(-4)	0.2908*** (0.0969)
LnMS	0.1365*** (0.0322)
LnOC	-0.2385*** (0.0324)
LnOC(-1)	0.0452 (0.0377)
LnOC(-2)	0.0584** (0.0254)
C	5.1098 (1.2849)
R-squared	0.9998
F-statistics	12614.63

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.3 ARDL Bounds Test

Test Statistics	Value	k
F-statistics	12.3488	4
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

After establishing that variables are cointegrated, diagnostic tests are applied to verify whether the models are free from serial correlation (LM serial correlation test), heteroscedasticity (White test for heteroscedasticity) and model specification error (Ramsay RESET test) so that it does not lead to the misleading results. Table 4.4 represents the results of the diagnostic tests.

Table 4.4 Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	0.4630	**Prob. F(2,23)**	0.6351
Obs*R-squared	1.4706	**Prob. Chi-Square(2)**	0.4794
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	0.8014	**Prob. F(12,25)**	0.6461
Obs*R-squared	10.5566	**Prob. Chi-Square(12)**	0.5673
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	1.2761	24	0.2141
F-statistics	1.6284	(1,24)	0.2141

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

After confirming the long run relationship between the variables, long run coefficients are estimated by using ARDL approach for cointegration. Results of long run coefficients are presented in table 4.5. The results found that parameter of capital is statistically significant and positive. Labor force also has a positive and significant impact on economic growth. Coefficient of middle schooling (human capital) is also positive and significant but aggregate oil consumption has a negative but significant impact on economic growth. The negative impact of aggregate oil consumption on economic growth is due to the adverse current account balance of Pakistan because of the increase in demand of crude oil and other imports. Government should take measures to increase domestic energy supplies such as natural gas and coal to ensure energy supply as Pakistan is rich in natural resources. Due to high energy prices, there should be a shift from expensive imported fuel to indigenously available alternative fuel. The results of these findings are consistent with Chaudhry et al. (2012).

Table 4.5 Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (0.5095*LN_K + 0.5496*LN_LF + 0.4147*LN_MS - 0.4100*LN_OC + 15.5271)	
LnK	0.5095*** (0.0770)
LnLF	0.5496*** (0.0932)
LnMS	0.4147*** (0.0643)
LnOC	-0.4100*** (0.0956)
C	15.5271*** (0.8052)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

To estimate the short run dynamics, it is necessary to transform the ARDL model into Error Correction Representation. Error correction term (ECT) is the rate of adjustment that indicates how quickly variables adjust towards equilibrium and its negative sign represents the convergence in the short run. This term should be negative and statistically significant to establish the long run relationship among the variables. Table 4.6 reports the results of short run dynamics.

Table 4.6 Estimation of Short Run Dynamics

Dependent Variable: ΔLnY	
Variable	**Coefficient**
Δ(LnY(-1))	-0.1139 (0.1399)
LnK	-0.0147*** (0.0033)
ΔLnLF	-0.1403 (0.1001)
Δ(LnLF(-1))	0.0990 (0.1123)
Δ(LnLF(-2))	-0.2934*** (0.0998)
Δ(LnLF(-3))	-0.2611** (0.1317)
Δ(LnLF(-4))	-0.0847 (0.1209)
Δ(LnMS)	0.1486*** (0.0331)
Δ(LnOC)	-0.2077*** (0.0340)
Δ(LnOC(-1))	-0.0748** (0.0333)
Δ(LnOC(-2))	-0.0262 (0.0290)
ECT(-1)	-0.2813*** (0.0954)
C	0.4653*** (0.1084)
R-Squared	0.8429
F- statistics	11.1769
Durbin- Watson stat	2.0746

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively. Δ is the difference operator.*

Table 4.6 shows that the estimated coefficient of ECT is -0.28 which indicates that the deviation from the long-term equilibrium is corrected by nearly 28 percent over the following year.

Negative and significant coefficient of the ECT shows that economic growth, capital stock, labor force, human capital and aggregate oil consumption have long run relationship in Pakistan.

After establishing the short run dynamics of the ARDL model, stability of the parameters are analyzed by CUSUM and CUSUMSQ tests. If the model lies between the critical bounds that means model is stable and null hypothesis is not rejected. Figure 4.1 and 4.2 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable and null hypothesis is accepted.

Figure 4.1: CUSUM Test

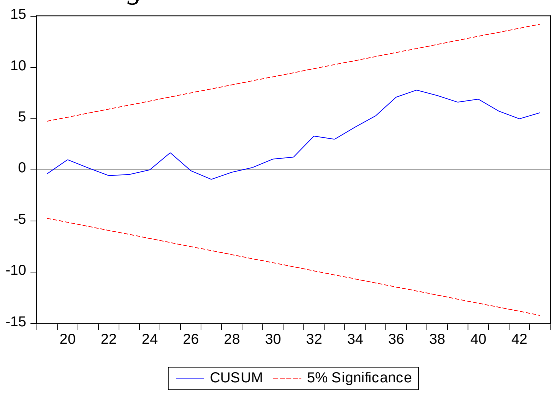
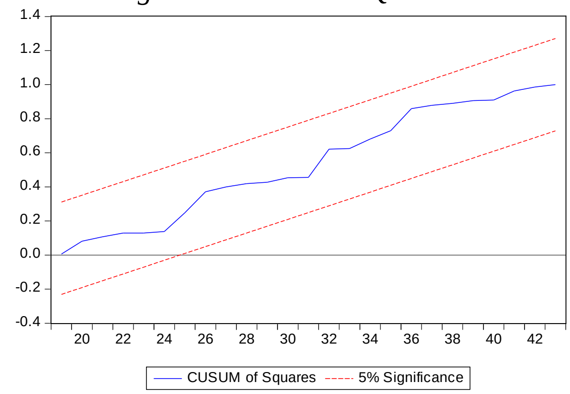


Figure 4.2: CUSUMSQ Test



4.3.1.2. Short Run and Long Run Causality

The ARDL through bound test confirms the existence or absence of the long run relationship among the variables but it does not tell us the direction of causality that which variable causes the other. For this purpose, ECM and Granger causality are used to determine the direction of causality. Table 4.7 summarizes the short run and long run causality.

Table 4.7 Results of Short Run and Long Run Causality

Dep. Variable	**Short Run Causality (Chi-Square Test)**					**Long Run Causality**
	ΔLnY	**LnK**	**ΔLnLF**	**ΔLnMS**	**ΔLnOC**	**ECT(-1)**
ΔLnY	-	6.8190 (0.0331)	1.1528 (0.5619)	0.8389 (0.6574)	1.9458 (0.3780)	8.700482 (0.0032)
LnK	2.1329 (0.3442)	-	0.5397 (0.7635)	5.9873 (0.0501)	2.8639 (0.2388)	-
ΔLnLF	0.9320 (0.6275)	1.0361 (0.5957)	-	0.9987 (0.6069)	1.3777 (0.5022)	-
ΔLnMS	1.4796 (0.4772)	0.3260 (0.8496)	0.0310 (0.9846)	-	0.1832 (0.9125)	-
ΔLnOC	2.5709 (0.2765)	0.5021 (0.7780)	1.4469 (0.4851)	0.9884 (0.6101)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

The results of the causality in the short run show that there is unidirectional causality running from capital stock to economic growth. For other equations in Table 4.7, the results of causality revealed that only human capital cause the capital stock while all others are insignificant which means that there is no short run causality exists in the system.

4.2.2. Results for Model of Disaggregate Oil Consumption

4.2.2.1. Long Run and Short Run Dynamics

The results of bound test in table 4.9 shows that F-statistics falls above the upper bounds at 1% significance level, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.8 and table 4.9 respectively.

Table 4.8 Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (6, 3, 3, 3, 3, 2, 1, 3)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.5468** (0.1949)	**LnIOC**	0.0271 (0.0217)
LnY(-2)	-0.8568** (0.2969)	**LnIOC(-1)**	-0.0050 (0.0210)
LnY(-3)	-0.2988 (0.2302)	**LnIOC(-2)**	0.0101 (0.0179)
LnY(-4)	-0.3596 (0.2166)	**LnIOC(-3)**	0.0511* (0.0220)
LnY(-5)	-0.4985** (0.1919)	**LnAOC**	-0.0204 (0.0211)
LnY(-6)	0.9165*** (0.2198)	**LnAOC(-1)**	0.0203 (0.0186)
LnK	2.6270** (0.7813)	**LnAOC(-2)**	-0.0519** (0.0158)
LnK(-1)	0.4761 (0.9538)	**LnTOC**	-0.1243 (0.0890)
LnK(-2)	-0.0605 (1.2142)	**LnTOC(-1)**	0.1373* (0.0628)
LnK(-3)	-1.6759* (0.6879)	**LnPOC**	-0.0306 (0.0162)
LnLF	-0.1190 (0.2093)	**LnPOC(-1)**	0.0042 (0.0149)
LnLF(-1)	0.6288** (0.1865)	**LnPOC(-2)**	-0.0042 (0.0106)
LnLF(-2)	0.2106 (0.2757)	**LnPOC(-3)**	-0.0392* (0.0105)
LnLF(-3)	0.3400 (0.1712)	**C**	2.5856 (3.7825)

LnMS	0.1727** (0.0511)	**R-squared**	0.9999
LnMS(-1)	-0.1265 (0.0695)	**F-statistic**	5278.574
LnMS(-2)	-0.1275* (0.0630)		
LnMS(-3)	-0.1635 (0.0942)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.9 ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	5.769316	7
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.03	3.13
5%	2.32	3.5
2.5%	2.6	3.84
1%	2.96	4.26

The results of the diagnostic tests shows that the selected ARDL model is free from serial correlation, heteroscedasticity and model specification error. Table 4.10 represents the results of the diagnostic tests.

Table 4.10 Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	2.463510	**Prob. F(2,3)**	0.2328
Obs*R-squared	22.99726	**Prob. Chi-Square(2)**	0.0000
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	1.320154	**Prob. F(31,5)**	0.4128
Obs*R-squared	32.97167	**Prob. Chi-Square(31)**	0.3708
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	0.179704	4	0.8661
F-statistics	0.032293	(1,4)	0.8661

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

After confirming that variables are cointegrated, long run coefficients are estimated by using ARDL approach for cointegration. Results of long run coefficients are reported in table 4.11. The results found that parameter of capital stock and labor force have positive and significant impact on economic growth. Coefficient of middle schooling (human capital) is significant but has a negative impact on economic growth. Oil consumption in industry and transport sectors have positive impact but oil consumption in industry sector has significant effect while oil consumption in transport sector has insignificant effect. The coefficients of oil consumption in agriculture and power sectors have a negative and significant effect on economic growth of Pakistan.

Table 4.11 Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (0.8815*LN_K + 0.6839*LN_LF -0.1579*LN_MS + 0.0537*LN_ICO -0.0336*LN_ACO + 0.0084*LN_TCO -0.0450*LN_PCO + 1.6677)	
LnK	0.8815*** (0.1023)
LnLF	0.6839*** (0.0909)
LnMS	-0.1579* (0.0780)
LnIOC	0.0537** (0.0181)
LnAOC	-0.0336* (0.0149)
LnTOC	0.0084 (0.0623)
LnPOC	-0.0450** (0.0126)
C	1.6677 (2.1968)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.12 Estimation of Short Run Dynamics

Dependent Variable: ∆LnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
∆(LnY(-1))	1.0699*** (0.1756)	**∆(LnIOC)**	0.0237 (0.0116)
∆(LnY(-2))	0.5657 (0.2411)	**∆(LnIOC(-1))**	-0.0667** (0.0138)
∆(LnY(-3))	-0.1735 (0.1579)	**∆(LnIOC(-2))**	-0.0704** (0.0141)
∆(LnY(-4))	-0.5389* (0.1780)	**∆(LnIOC(-3))**	-0.0183 (0.0151)
∆(LnY(-5))	-1.0448** (0.1922)	**∆(LnAOC)**	-0.0143 (0.0108)
∆(LnY(-6))	-0.3306 (0.2283)	**∆(LnAOC(-1))**	0.0556** (0.0143)
LnK	2.5028** (0.6021)	**∆(LnAOC(-2))**	0.0260 (0.0202)
LnK(-1)	-0.2993 (0.7950)	**LnTOC**	-0.1532** (0.0413)
LnK(-2)	0.0720 (0.8305)	**LnTOC(-1)**	0.1105 (0.0470)
LnK(-3)	-2.2393** (0.6667)	**∆(LnPOC)**	-0.0257* (0.0085)

Δ(LnLF)	-0.1130 (0.1494)	**Δ(LnPOC(-1))**	0.0477** (0.0111)
Δ(LnLF(-1))	-0.7702** (0.2292)	**Δ(LnPOC(-2))**	0.0507** (0.0096)
Δ(LnLF(-2))	-0.3076 (0.1410)	**Δ(LnPOC(-3))**	0.0073 (0.0085)
Δ(LnLF(-3))	-0.1835 (0.1033)	**ECT(-1)**	-1.7987*** (0.2791)
Δ(LnMS)	0.1620** (0.0345)	**C**	-0.4020 (0.7579)
Δ(LnMS(-1))	0.3873** (0.0865)	**R-squared**	0.99217
Δ(LnMS(-2))	0.2042** (0.0548)	**F-statistics**	11.8766
Δ(LnMS(-3))	0.0502 (0.0578)	**Durbin-Watson stat**	2.9122

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively. Δ is the difference operator.*

Figure 4.3 and 4.4 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

Figure 4.3: CUSUM Test

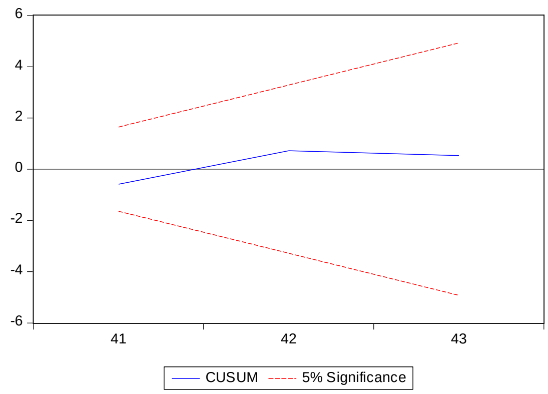
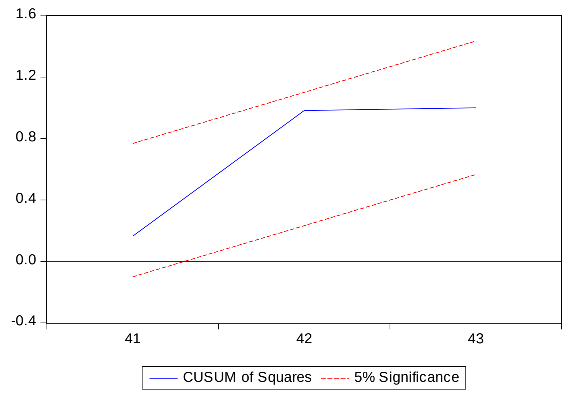


Figure 4.4: CUSUMSQ Test



4.3.2.2. Short Run and Long Run Causality

The results in the short run shows that there exists unidirectional causality that runs from human capital to capital stock while all others are insignificant which means that there is no short run causality exists in the system. Table 4.13 summarizes the short run and long run causality.

Table 4.13 Results of Short Run and Long Run Causality

Dep. Var	Short Run Causality (Chi-Square Test)								Long Run Causality
	Δlny	lnk	Δlnlf	Δlnms	Δlnioc	Δlnaoc	lntoc	Δlnpoc	ECT(-1)
Δlny	-	2.5684 (0.2769)	1.6603 (0.4360)	1.3709 (0.5039)	0.4107 (0.8144)	0.2205 (0.8956)	2.2737 (0.3208)	1.1814 (0.5539)	41.5318 (0.0000)
lnk	0.2097 (0.9004)	-	0.9720 (0.6151)	5.3971 (0.0673)	1.8229 (0.4019)	2.2712 (0.3212)	0.3973 (0.8198)	1.7318 (0.4207)	-
Δlnlf	2.2574 (0.3235)	0.7278 (0.6949)	-	1.4039 (0.4956)	0.1527 (0.9265)	1.5411 (0.4628)	0.7423 (0.6899)	1.0363 (05956)	-
Δlnms	1.0409 (0.5943)	0.2377 (0.8879)	0.1032 (0.9497)	-	0.0757 (0.9628)	0.7295 (0.6944)	0.2076 (0.9014)	0.1622 (0.9221)	-
Δlnioc	1.0033 (0.6055)	1.6621 (0.4356)	2.4218 (0.2979)	2.4427 (0.2948)	-	0.5894 (0.7448)	0.4909 (0.7824)	0.0577 (0.9715)	-
Δlnaoc	3.1173 (0.2104)	0.6735 (0.7141)	1.9644 (0.3745)	1.5671 (0.4658)	2.7217 (0.2564)	-	0.2127 (0.8991)	0.0388 (0.9808)	-
Lntoc	1.8646 (0.3936)	2.4250 (0.2975)	0.9663 (0.6168)	0.1431 (0.9310)	0.1120 (0.9455)	1.2170 (0.5442)	-	0.9018 (0.6371)	-
Δlnpoc	1.1096 (0.5742)	2.3378 (0.3107)	0.1035 (0.9496)	0.8528 (0.6529)	2.8360 (0.2422)	2.3596 (0.3073)	0.1507 (0.9274)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

4.3. Results for Model of Coal Consumption

4.3.1. Results for Model of Aggregate Coal Consumption

4.3.1.1. Long Run and Short Run Dynamics

The results of bound test in table 4.15 shows that F-statistics falls above the upper bounds at 1% significance level, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.14 and table 4.15 respectively.

Table 4.14: Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (3, 2, 3, 1, 1)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.8301*** (0.1787)	**LnLF(-3)**	0.4382** (0.1697)
LnY(-2)	-0.2242 (0.2292)	**LnMS**	0.2551*** (0.0599)
LnY(-3)	-0.1149 (0.1573)	**LnMS(-1)**	-0.1546*** (0.0490)
LnK	-0.1415 (0.5948)	**LnCC**	0.0520** (0.0242)
LnK(-1)	0.5621 (0.6109)	**LnCC(-1)**	-0.0300 (0.0244)

LnK(-2)	-0.3000 (0.2021)	**C**	8.7555** (3.4351)
LnLF	0.1264 (0.1441)	**R-squared**	0.9997
LnLF(-1)	0.2657 (0.2020)	**F-statistics**	5261.424
LnLF(-2)	-0.4057** (0.1868)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.15: ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	4.365119	4
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

The results of the diagnostic tests shows that the selected ARDL model is free from serial correlation, heteroscedasticity and model specification error. Table 4.16 represents the results of the diagnostic tests.

Table 4.16: Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	0.313266	**Prob. F(2,21)**	0.7344
Obs*R-squared	1.129851	**Prob. Chi-Square(2)**	0.5684
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	0.342226	**Prob. F(15,23)**	0.9820
Obs*R-squared	7.116171	**Prob. Chi-Square(15)**	0.9543
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	0.017185	22	0.9864
F-statistics	0.000295	(1, 22)	0.9864

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

The results of the long run coefficients found that parameter of capital stock is positive but insignificant. Labor force and middle schooling (human capital) have positive and significant impact on economic growth. The coefficient of aggregate coal consumption has a positive and insignificant impact on real GDP. Positive and insignificant impact shows that any increase in aggregate coal consumption might not boost the economic growth. Results of long run coefficients are reported in table 4.17.

Table 4.17 Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (0.2370*LN_K + 0.8342*LN_LF + 0.1975*LN_MS + 0.0431*LN_CC + 17.2006)	
LnK	0.2370 (0.1397)
LnLF	0.8342*** (0.0958)
LnMS	0.1975** (0.0880)
LnCC	0.0431 (0.0476)
C	17.2006*** (3.5115)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

The results of the short run dynamics in table 4.18 shows that the estimated coefficient of ECT is -0.75 which indicates that the deviation from the long-term equilibrium is corrected by nearly 75 percent over the following year. Negative and significant coefficient of the ECT shows that economic growth, capital stock, labor force, human capital and aggregate coal consumption have long run relationship in Pakistan. Table 4.18 reports the estimation of short run dynamics.

Table 4.18 Estimation of Short Run Dynamics

Dependent Variable: ΔLnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
Δ(LnY(-1))	0.3711** (0.1733)	**Δ(LnMS)**	0.2858*** (0.0434)
Δ(LnY(-2))	0.3434** (0.1418)	**Δ(LnMS(-1))**	0.0679 (0.0471)
Δ(LnY(-3))	-0.0835 (0.1248)	**Δ(LnCC)**	0.0740*** (0.0191)
LN_K	-0.6483 (0.4958)	**Δ(LnCC(-1))**	0.0283 (0.0192)
LN_K(-1)	1.6672* (0.8518)	**ECT(-1)**	-0.7464*** (0.1806)
LN_K(-2)	-0.9991** (0.3870)	**C**	-0.6096 (0.5008)
Δ(LnLF)	0.1227 (0.1283)	**R-Squared**	0.8098
Δ(LnLF(-1))	-0.2396 (0.1655)	**F- statistics**	6.5279
Δ(LnLF(-2))	-0.5690*** (0.1402)	**Durbin- Watson stat**	2.1627
Δ(LnLF(-3))	-0.3119** (0.1463)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*
Δ is the difference operator.

Figure 4.5 and 4.6 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

Figure 4.5: CUSUM Test

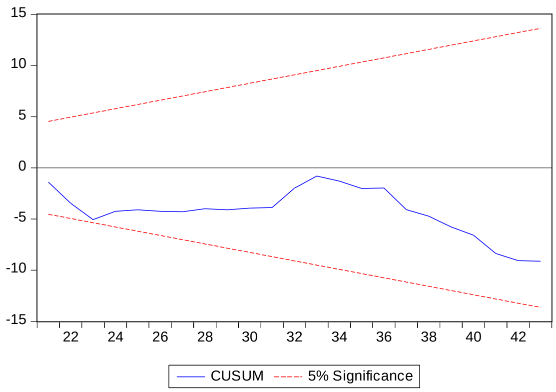
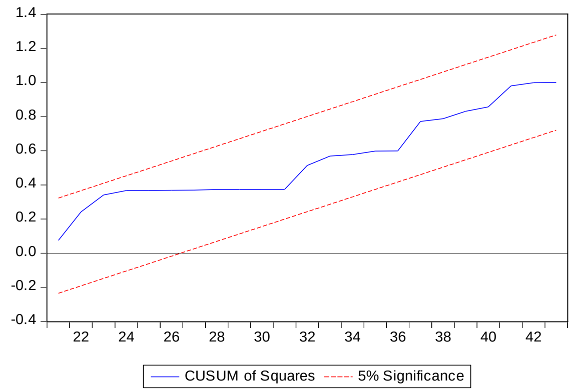


Figure 4.6: CUSUMSQ Test



4.3.1.2. Short Run and Long Run Causality

The results of the causality in the short run shows that there is unidirectional causality running from capital stock to economic growth. As for the short run causality test for other equations in Table 4.19 revealed that there exists a unidirectional causality running from human capital to capital stock and from economic growth to aggregate coal consumption. Table 4.19 summarizes the short run and long run causality.

Table 4.19: Results of Short Run and Long Run Causality

Dep. Variable	Short Run Causality (Chi-Square Test)					Long Run Causality
	Δln_y	**ln_k**	**Δln_lf**	**Δln_ms**	**Δln_cc**	**ECT(-1)**
Δln_y	-	6.0795 (0.0478)	1.2918 (0.5242)	1.2603 (0.5325)	1.7544 (0.4159)	17.0837 (0.0004)
ln_k	2.9720 (0.2263)	-	0.5344 (0.7655)	7.1757 (0.0277)	3.2904 (0.1930)	-
Δln_lf	1.0386 (0.5949)	2.2768 (0.3203)	-	0.5874 (0.7455)	4.3461 (0.1138)	-
Δln_ms	0.0302 (0.9850)	0.5466 (0.7609)	0.3421 (0.8428)	-	2.0019 (0.3675)	-
Δln_cc	6.8725 (0.0322)	0.4544 (0.7968)	0.1174 (0.9430)	1.2465 (0.5362)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

4.3.2. Results for Model of Disaggregate Coal Consumption

4.3.2.1. Long Run and Short Run Dynamics

The results of bound test in table 4.21 shows that F-statistics falls above the upper bounds at 1% significance level, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.20 and table 4.21 respectively.

Table 4.20: Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (3, 2, 3, 1, 1)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.6593*** (0.1226)	**LnPCC**	-0.0075** (0.0036)
LnK	0.2478 (0.4212)	**LnBKCC**	-0.0123 (0.0206)
LnK(-1)	0.6106 (0.4760)	**LnBKCC(-1)**	-0.0391* (0.0222)
LnK(-2)	-0.5629*** (0.1905)	**LnBKCC(-2)**	-0.0444* (0.0235)
LnLF	0.1162 (0.0961)	**LnBKCC(-3)**	-0.0541** (0.0217)
LnMS	0.1691*** (0.0448)	**C**	1.4820 (1.5443)
LnMS(-1)	-0.0220 (0.0622)	**R-squared**	0.9997
LnMS(-2)	-0.0952* (0.0485)	**F-statistic**	6908.569

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.21: ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	5.702867	5
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.26	3.35
5%	2.62	3.79
2.5%	2.96	4.18
1%	3.41	4.68

Table 4.22: Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	1.368117	**Prob. F(2,22)**	0.2754
Obs*R-squared	4.314040	**Prob. Chi-Square(2)**	0.1157
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	1.105154	**Prob. F(14,24)**	0.4012
Obs*R-squared	15.28708	**Prob. Chi-Square(14)**	0.3588
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	0.559824	23	0.5810
F-statistics	0.313403	(1, 23)	0.5810

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

The results of the diagnostic tests shows that the selected ARDL model is free from serial correlation, heteroscedasticity and model specification error. Table 4.22 represents the results of the diagnostic tests.

The results of the long run coefficients found that capital stock and labor force have a positive and significant impact on real GDP. The coefficient of human capital has positive but insignificant impact. While, coefficients of coal consumption in power and brick kilns sector have significant but negative impact on economic growth. This shows that any increase in the consumption of coal in these sectors will reduce the economic growth. The results of long run coefficients are reported in table 4.23.

Table 4.23 Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (0.8676*LN_K + 0.3410*LN_LF + 0.1521*LN_MS -0.0220*LN_PCC -0.4400*LN_BKCC + 4.3494)	
LnK	0.8676*** (0.1813)
LnLF	0.3410* (0.1961)
LnMS	0.1521 (0.1130)
LnPCC	-0.0220** (0.0098)
LnBKCC	-0.4400** (0.1600)
C	4.3494 (3.6947)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

The results of the short run dynamics in table 4.24 shows that the estimated coefficient of ECT is -0.41 which indicates that the deviation from the long-term equilibrium path is corrected by nearly 41 percent over the following year. Negative and significant coefficient of the ECT shows that economic growth, capital stock, labor force, human capital and coal consumption in power and brick kilns sectors have long run relationship in Pakistan. Table 4.24 reports the results of short run dynamics.

Table 4.24: Estimation of Short Run Dynamics

Dependent Variable: ΔLnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
Δ(LnY(-1))	-0.0117 (0.1322)	**Δ(LnBKCC(-1))**	0.1428*** (0.0311)
LnK	-0.4719 (0.4435)	**Δ(LnBKCC(-2))**	0.0927*** (0.0235)

LnK(-1)	1.9253*** (0.6861)	**Δ(LnBKCC(-3))**	0.0374** (0.0181)
LnK(-2)	-1.4389*** (0.3146)	**ECT(-1)**	-0.4067*** (0.0835)
Δ(LnLF)	0.0670 (0.1242)	**C**	-0.4489 (0.4308)
Δ(LnMS)	0.1918*** (0.0359)	**R-squared**	0.8229
Δ(LnMS(-1))	0.1017** (0.0490)	**F-statistics**	7.9635
Δ(LnMS(-2))	0.0122 (0.0430)	**Durbin-Watson stat**	1.6554
Δ(LnPCC)	-0.0094*** (0.0024)		
Δ(LnBKCC)	0.0020 (0.0206)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively. Δ is the difference operator.*

Figure 4.7 and 4.8 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

Figure 4.7: CUSUM Test

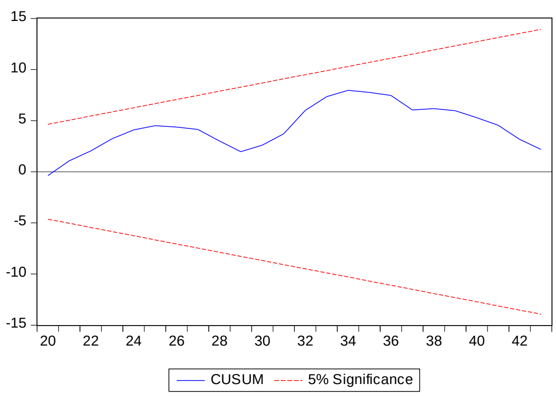
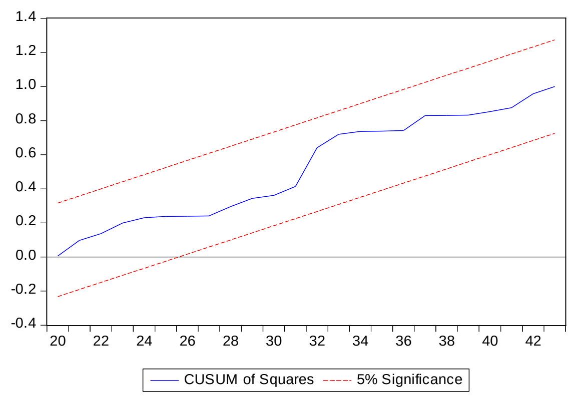


Figure 4.8: CUSUMSQ Test



4.4.2.2. Short Run and Long Run Causality

The results of causality in the short run in table 4.25 shows there exists a unidirectional causality running from human capital to capital stock, coal consumption in power and brick kiln sector to human capital and from economic growth to coal consumption in brick kiln sector. Table 4.25 summarizes the short run and long run causality.

Table 4.25: Results of Short Run and Long Run Causality

Dep. Var	Short Run Causality (Chi-Square Test)						Long Run Causality
	Δln_y	**ln_k**	**Δln_lf**	**Δln_ms**	**Δln_pcc**	**Δln_bkcc**	**ECT(-1)**
Δln_y	-	3.4017 (0.1825)	1.2105 (0.5459)	3.7040 (0.1569)	3.9973 (0.1355)	1.1473 (0.5635)	23.7369 (0.0000)
ln_k	1.9685 (0.3737)	-	0.298121 (0.8615)	4.9861 (0.0827)	1.4975 (0.4730)	1.4970 (0.4731)	-
Δln_lf	0.9837 (0.6115)	1.2010 (0.5485)	-	3.2027 (0.2016)	2.3074 (0.3155)	1.0500 (0.5916)	-
Δln_ms	0.9495 (0.6220)	2.5393 (0.2809)	1.0305 (0.5974)	-	7.7440 (0.0208)	5.6800 (0.0584)	-
Δln_pcc	1.5391 (0.4632)	1.4363 (0.4877)	0.1142 (0.9445)	2.9425 (0.2296)	-	1.5960 (0.4502)	-
Δln_bkcc	16.5359 (0.0003)	1.3815 (0.5012)	0.3131 (0.8551)	0.0922 (0.9550)	3.9443 (0.1392)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

4.4. Results for Model of Gas Consumption

4.4.1. Results for Model of Aggregate Gas Consumption

4.4.1.1. Long Run and Short Run Dynamics

The results of bound test in table 4.27 shows that F-statistics falls above the upper bounds at 1% significance level, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.26 and table 4.27 respectively.

Table 4.26: Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (1, 2, 4, 2, 0)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.5849*** (0.1482)	**LnLF(-4)**	0.3102** (0.1425)
LnK	-1.2499** (0.5112)	**LnMS**	0.2257*** (0.0456)
LnK(-1)	1.9104** (0.7587)	**LnMS(-1)**	-0.0551 (0.0610)
LnK(-2)	-0.6762** (0.3273)	**LnMS(-2)**	-0.0809* (0.0462)
LnLF	-0.0109 (0.1333)	**LnGC**	0.1407*** (0.0336)
LnLF(-1)	0.1220 (0.1731)	**C**	9.2389*** (2.4114)

LnLF(-2)	-0.2684 (0.1669)	**R-squared**	0.9998
LnLF(-3)	0.0812 (0.1612)	**F-statistics**	7119.753

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.27: ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	5.131320	4
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

The results of the diagnostic tests shows that the selected ARDL model is free from serial correlation, heteroscedasticity and model specification error. Table 4.28 represents the results of the diagnostic tests.

Table 4.28: Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	1.067905	**Prob. F(2,23)**	0.3602
Obs*R-squared	3.313860	**Prob. Chi-Square(2)**	0.1907
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	0.963369	**Prob. F(13,25)**	0.5098
Obs*R-squared	13.01649	**Prob. Chi-Square(13)**	0.4465
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	1.182401	24	0.2486
F-statistics	1.398072	(1, 24)	0.2486

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

Results of long run coefficients are reported in table 4.29. The coefficient of capital has negative but insignificant impact on economic growth. While, labor force, total enrollment in middle schools (human capital) and aggregate gas consumption are significant and positively effects the economic growth of Pakistan. This means that any increase in aggregate gas consumption will increase the economic growth while reduction in it can decrease the GDP. So, government should made expansionary natural gas policies which will be beneficial for our country. Also by substituting with other kinds of fossil fuels with gas should be regarded as a viable policy as this will reduce emission problems in the country. Being a country with abundant natural gas resources, by pursuing such policies can be beneficial.

Table 4.29: Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (-0.0377*LN_K + 0.5639*LN_LF + 0.2162*LN_MS + 0.3389*LN_GC + 22.2556)	
LnK	-0.0377 (0.1826)
LnLF	0.5639*** (0.1226)
LnMS	0.2162** (0.1020)
LnGC	0.3389*** (0.1101)
C	22.2556*** (4.0127)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

The results of the short run dynamics in table 4.30 shows that the estimated coefficient of ECT is -0.47 which indicates that the deviation from the long-term equilibrium path by nearly 47 percent over the following year. Negative and significant coefficient of the ECT shows that economic growth, capital stock, labor force, human capital and aggregate gas consumption have long run relationship in Pakistan. Table 4.30 reports the results of short run dynamics.

Table 4.30: Estimation of Short Run Dynamics

Dependent Variable: ∆LnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
∆(LnY(-1))	0.0116 (0.1655)	**∆(LnMS)**	0.2031*** (0.0436)
LnK	-0.9694* (0.5393)	**∆(LnMS(-1))**	0.0562 (0.0480)
LnK(-1)	1.5540* (0.8713)	**∆(LnMS(-2))**	0.0100 (0.0434)
LnK(-2)	-0.5689 (0.3540)	**∆(LnGC)**	0.1789*** (0.0572)
∆(LnLF)	-0.0589 (0.1247)	**ECT(-1)**	-0.4739*** (0.1274)
∆(LnLF(-1))	-0.1547 (0.1420)	**C**	-0.4793 (0.4931)
∆(LnLF(-2))	-0.4422*** (0.1295)	**R-Squared**	0.7947
∆(LnLF(-3))	-0.4057** (0.1732)	**F- statistics**	6.3589
∆(LnLF(-4))	-0.2159 (0.1780)	**Durbin- Watson stat**	2.3290

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively. ∆ is the difference operator.*

Figure 4.9 and 4.10 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

Figure 4.9: CUSUM Test

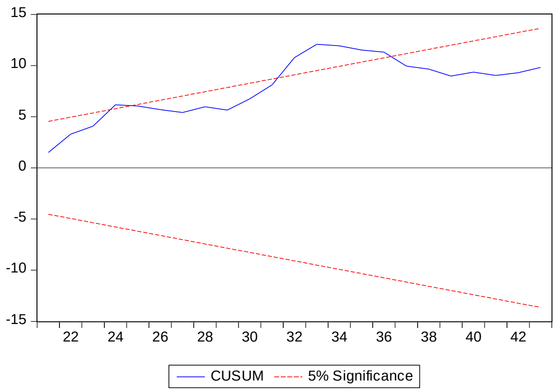
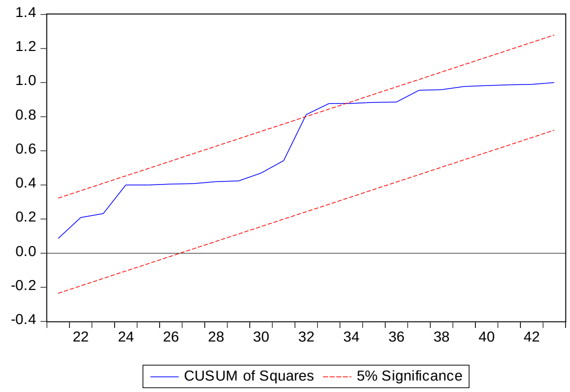


Figure 4.10: CUSUMSQ Test



4.4.1.2. Short Run and Long Run Causality

The results in the short run in table 4.31 shows that that the causality is running from human capital and aggregate gas consumption to capital stock. As for the short run causality test for other equations in table 4.31 revealed that all others variables in the equations are insignificant which means that there is no short run causality exists in the system. Table 4.31 summarizes the short run and long run causality.

Table 4.31: Results of Short Run and Long Run Causality

Dep. Var	**Short Run Causality (Chi-Square Test)**					**Long Run Causality**
	Δln_y	**ln_k**	**Δln_lf**	**Δln_ms**	**Δln_gc**	**ECT(-1)**
Δln_y	-	4.5209 (0.1043)	2.1194 (0.3466)	1.7000 (0.4274)	0.2355 (0.8889)	13.8318 (0.0002)
ln_k	3.5279 (0.1714)	-	0.2208 (0.8955)	8.1310 (0.0172)	5.2566 (0.0722)	-
Δln_lf	0.8991 (0.6379)	0.0661 (0.9675)	-	1.3796 (0.5017)	2.7048 (0.2586)	-
Δln_ms	0.7008 (0.7044)	0.1050 (0.9488)	0.0657 (0.9677)	-	0.4734 (0.7892)	-
Δln_gc	4.5199 (0.1044)	2.5644 (0.2774)	0.2201 (0.8958)	1.9623 (0.3749)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

4.4.2. Results for Model of Disaggregate Gas Consumption

4.4.2.1. Long Run and Short Run Dynamics

The results of bound test in table 4.33 shows that F-statistics falls above the upper bounds at 1% significance level, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.32 and table 4.33 respectively.

Table 4.32: Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (1, 0, 0, 0, 0, 1, 0, 0, 1)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.5158*** (0.1030)	**LnFGC**	0.0631*** (0.0185)
LnK	-0.0341 (0.0281)	**LnIGC**	-0.0041 (0.0358)
LnLF	0.1653 (0.1109)	**LnPGC**	0.0664** (0.0265)
LnMS	0.1139** (0.0497)	**LnPGC(-1)**	0.0445 (0.0295)
LnCoGC	0.0811 (0.0718)	**C**	11.0575*** (2.2875)
LnCeGC	-0.0125 (0.0081)	**R-squared**	0.9996
LnCeGC(-1)	-0.0117 (0.0082)	**F-statistics**	6988.164

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 433: ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	4.158959	8
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	1.95	3.06
5%	2.22	3.39
2.5%	2.48	3.7
1%	2.79	4.1

The results of the diagnostic tests shows that the selected ARDL model is not suffering from serial correlation, heteroscedasticity and model specification error. Table 4.34 presents the results of the diagnostic tests.

Table 4.34: Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	0.8541	**Prob. F(2,28)**	0.4365
Obs*R-squared	2.4150	**Prob. Chi-Square(2)**	0.2989
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	1.0584	**Prob. F(11,30)**	0.4245
Obs*R-squared	11.7423	**Prob. Chi-Square(11)**	0.3833
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	1.7650	29	0.0881
F-statistics	3.1153	(1, 29)	0.0881

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

The results of the long run dynamics found that parameter of capital has negative and insignificant impact on economic growth. Labor force is positive but insignificant. Coefficient of middle schooling (human capital) is also positive and significant. The parameter of gas consumption in cement sector is significant but real GDP affected negatively whereas gas consumption in power and fertilizer sectors are positive and significant. Gas consumption in commercial sector is positive but insignificant whereas its consumption in industry sector is negative and insignificant. The positive and significant impact of gas consumption in power and fertilizer sectors shows that any increase of consumption in these sector will boost the economic growth. Results of long run coefficients are reported in table 4.35

Table 4.35: Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (-0.0704*LN_K + 0.3415*LN_LF + 0.2354*LN_MS +0.1676*LN_COCG -0.0501*LN_CECG +0.1304*LN_FCG -0.0084*LN_ICG + 0.2291*LN_PCG + 22.8387)	
LnK	-0.0704 (0.0580)
LnLF	0.3415 (0.2233)
LnMS	0.2354*** (0.0650)
LnCoGC	0.1676 (0.1479)
LnCeGC	-0.0501*** (0.0110)
LnFGC	0.1304*** (0.0323)
LnIGC	-0.0084 (0.0743)
LnPGC	0.2291*** (0.0518)

C	22.8387*** (1.1068)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

The results of the short run dynamics in table 4.36 shows that the estimated coefficient of ECT is -0.56 which indicates that the deviation from the long-term equilibrium path is corrected by nearly 56 percent over the following year. Negative and significant coefficient of the ECT shows that economic growth, capital stock, labor force, human capital and aggregate coal consumption have long run relationship in Pakistan.

Table 4.36: Estimation of Short Run Dynamics

Dependent Variable: ΔLnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
Δ(LnY(-1))	0.1556 (0.1374)	**Δ(LnIGC)**	0.0088 (0.0443)
LnK	0.0035 (0.0122)	**Δ(LnPGC)**	0.0565** (0.0235)
Δ(LnLF)	0.0493 (0.1380)	**Δ(LnPGC(-1))**	-0.0298 (0.0269)
Δ(LnMS)	0.1420*** (0.0409)	**ECT(-1)**	-0.5670*** (0.1194)
LnCoGC	-0.0018 (0.0153)	**C**	-0.0914 (0.2228)
Δ(LnCeGC)	-0.0136* (0.0068)	**R-Squared**	0.6733
Δ(LnCeGC(-1))	0.0083 (0.0077)	**F- statistics**	4.8093
Δ(LnFGC)	0.0439** (0.0178)	**Durbin- Watson stat**	2.2502

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*
Δ is the difference operator.

Figure 4.11 and 4.12 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

Figure 4.11: CUSUM Test

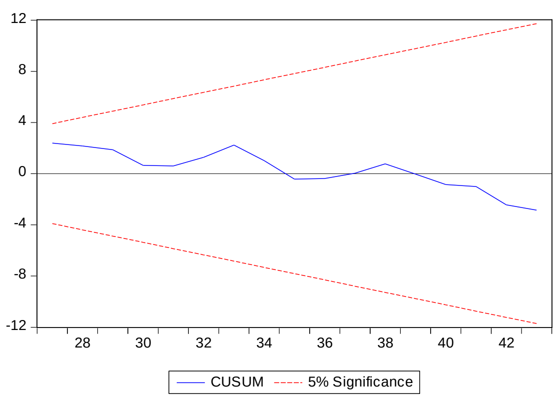
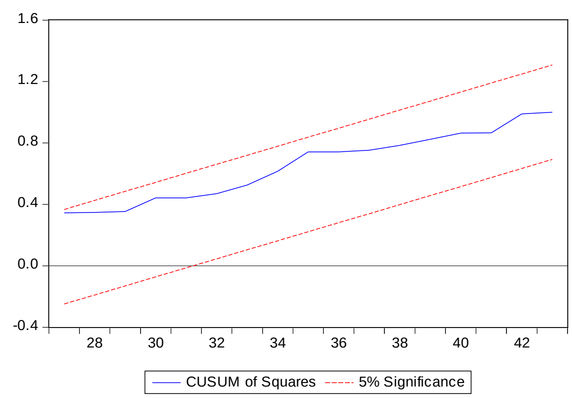


Figure 4.12: CUSUMSQ Test



4.4.2.2. Short Run and Long Run Causality

The results of the causality in the short run shows that the unidirectional causality is running from economic growth, human capital, gas consumption in commercial, fertilizer and industrial sector to capital stock. As for the short run causality test for other equations in Table 4.37 revealed that there is unidirectional causality running from economic growth and gas consumption in industrial sector to human capital, from gas consumption in cement sector to gas consumption in commercial sector and from economic growth to gas consumption in industrial sector. Table 4.37 summarizes the short run and long run causality.

Table 4.37: Results of Short Run and Long Run Causality

Dep. Var	**Short Run Causality (Chi-Square Test)**									**Long Run Causality**
	Δln_y	**ln_k**	**Δln_lf**	**Δln_ms**	**ln_cogc**	**Δln_cegc**	**Δln_fgc**	**Δln_pgc**	**Δln_igc**	**ECT(-1)**
Δln_y	-	0.1398 (0.9325)	2.8404 (0.2417)	0.1689 (0.9190)	0.1435 (0.9308)	0.6723 (0.7145)	1.4561 (0.4828)	1.5423 (0.4625)	0.2896 (0.8652)	23.3744 (0.0000)
ln_k	5.1667 (0.0755)	-	3.7404 (0.1541)	18.2584 (0.0001)	12.9880 (0.0015)	1.0309 (0.5972)	9.0597 (0.0108)	2.0413 (0.3604)	8.7010 (0.0129)	-
Δln_lf	0.1893 (0.9097)	0.1577 (0.9242)	-	2.2404 (0.3262)	0.0719 (0.9647)	1.9405 (0.3790)	0.6568 (0.7201)	1.0722 (0.5850)	1.0502 (0.5915)	-
Δln_ms	5.1982 (0.0743)	3.1273 (0.2094)	1.0900 (0.5798)	-	1.3036 (0.5211)	0.3815 (0.8263)	2.3633 (0.3068)	1.6518 (0.4378)	7.2177 (0.0271)	-
ln_cogc	1.4271 (0.4899)	4.2706 (0.1182)	1.2367 (0.5388)	0.1519 (0.9268)	-	5.3924 (0.0675)	1.2513 (0.5349)	0.8032 (0.6693)	0.6916 (0.7077)	-
Δln_cegc	0.5567 (0.7570)	3.9303 (0.1401)	0.2683 (0.8745)	0.9722 (0.6150)	4.0013 (0.1352)	-	0.3531 (0.8382)	1.6005 (0.4492)	2.4266 (0.2972)	-
Δln_fgc	1.2686 (0.5303)	0.0739 (0.9637)	1.1223 (0.5705)	2.3618 (0.3070)	0.0791 (0.9612)	0.6340 (0.7283)	-	0.6740 (0.7139)	2.1134 (0.3476)	-
Δln_pgc	0.6184 (0.7340)	1.6391 (0.4406)	0.2813 (0.8688)	0.4684 (0.7912)	1.6662 (0.4347)	0.9922 (0.6089)	0.5170 (0.7722)	-	0.4991 (0.7792)	-
Δln_igc	6.6833 (0.0354)	2.6054 (0.2718)	1.4866 (0.4756)	1.7764 (0.4114)	1.2150 (0.5447)	3.5648 (0.1682)	1.0048 (0.6051)	2.7321 (0.2551)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

4.5. Results for Model of Electricity Consumption

4.5.1. Results for Model of Aggregate Electricity Consumption

4.5.1.1. Long Run and Short Run Dynamics

The results of bound test in table 4.39 shows that F-statistics falls above the upper bounds at 1% significance level, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.38 and table 4.39 respectively.

Table 4.38: Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (6, 3, 3, 5, 5)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.2361 (0.1774)	**LnMS(-1)**	-0.0631 (0.0540)
LnY(-2)	-0.2253 (0.2034)	**LnMS(-2)**	-0.0417 (0.0552)
LnY(-3)	-0.4144** (0.1683)	**LnMS(-3)**	-0.0752 (0.0524)
LnY(-4)	-0.3081* (0.1637)	**LnMS(-4)**	0.1266** (0.0462)
LnY(-5)	0.0086 (0.1668)	**LnMS(-5)**	0.0508 (0.0445)
LnY(-6)	0.5445*** (0.1525)	**LnEC**	0.2036** (0.0720)
LnK	1.8714*** (0.5758)	**LnEC(-1)**	0.1528** (0.0673)
LnK(-1)	-0.7788 (0.8425)	**LnEC(-2)**	-0.2093** (0.0727)
LnK(-2)	0.8520 (0.8143)	**LnEC(-3)**	0.1756* (0.0855)
LnK(-3)	-1.1591 (0.4283)	**LnEC(-4)**	-0.3018*** (0.0911)
LnLF	0.1980 (0.1312)	**LnEC(-5)**	-0.2094** (0.0835)
LnLF(-1)	0.3213* (0.1533)	**C**	6.7729 (5.7283)
LnLF(-2)	-0.1896 (0.1611)	**R-squared**	0.9999
LnLF(-3)	0.5316** (0.1797)	**F-statistics**	7148.454
LnMS	0.2832*** (0.0431)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.39: ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	7.7741	4
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.25	4.49
1%	3.74	5.06

The results of the diagnostic tests shows that the selected ARDL model is free from serial correlation, heteroscedasticity and model specification error. Table 4.40 represents the results of the diagnostic tests.

Table 4.40: Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	2.980145	**Prob. F(2,8)**	0.1078
Obs*R-squared	15.79700	**Prob. Chi-Square(2)**	0.0004
Heteroscedasticity Test: Breusch-Pagan-Godfrey			
F-statistics	0.815125	**Prob. F(26,10)**	0.6797
Obs*R-squared	25.13846	**Prob. Chi-Square(26)**	0.5111
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	0.183990	9	0.8581
F-statistics	0.033852	(1, 9)	0.8581

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

The results found that parameters of capital stock, labor force and total enrollment in middle schooling (human capital) are positively and significantly impact the real GDP. The negative impact of the aggregate electricity consumption shows that any increase in its consumption might decrease the economic growth but its impact is not significant. The negative and insignificant impact of aggregate electricity consumption suggests that in order to boost the economic growth, government should introduced such reforms to shift the electricity consumption to cheap substitutes of energy. So, that economic growth can be increased. Results of long run coefficients are reported in table 4.41.

Table 4.41: Estimation of Long Run Dynamics

Variable	**Coefficient**
Cointeq = LN_Y - (0.6780*LN_K + 0.7435*LN_LF + 0.2422*LN_MS - 0.1628*LN_EC + 5.8460)	
LnK	0.6780*** (0.1566)
LnLF	0.7435*** (0.0277)
LnMS	0.2422*** (0.0690)
LnEC	-0.1628 (0.1233)
C	5.8460 (3.7146)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.42: Estimation of Short Run Dynamics

Dependent Variable: ΔLnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
Δ(LnY(-1))	0.3312 (0.4024)	**Δ(LnMS(-2))**	-0.1213*** (0.0568)
Δ(LnY(-2))	0.2484 (0.4214)	**Δ(LnMS(-3))**	-0.1873 (0.0429)
Δ(LnY(-3))	-0.2637 (0.2893)	**Δ(LnMS(-4))**	-0.0696 (0.0581)
Δ(LnY(-4))	-0.5867** (0.2505)	**Δ(LnMS(-5))**	0.0169 (0.0404)
Δ(LnY(-5))	-0.6070** (0.2152)	**LnEC**	0.2204** (0.0839)
Δ(LnY(-6))	-0.0842 (0.1298)	**LnEC(-1)**	0.3357** (0.1154)
LnK	1.8102** (0.7818)	**LnEC(-2)**	-0.1623 (0.1049)
LnK(-1)	-1.3019 (0.9745)	**LnEC(-3)**	0.1321 (0.1099)
LnK(-2)	0.6769 (0.9270)	**LnEC(-4)**	-0.2502* (0.1156)
LnK(-3)	-1.1901** (0.5200)	**LnEC(-5)**	-0.2698** (0.1050)
Δ(LnLF)	0.2110 (0.1287)	**ECT(-1)**	-1.2207** (0.4291)
Δ(LnLF(-1))	-0.3854 (0.2882)	**C**	0.0906 (6.6168)
Δ(LnLF(-2))	-0.5451* (0.2464)	**R-Squared**	0.9652
Δ(LnLF(-3))	-0.0871 (0.2224)	**F- statistics**	8.2140
Δ(LnMS)	0.2583*** (0.0543)	**Durbin- Watson stat**	2.6546
Δ(LnMS(-1))	-0.0411 (0.0578)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively. Δ is the difference operator.*

Figure 4.13: CUSUM Test

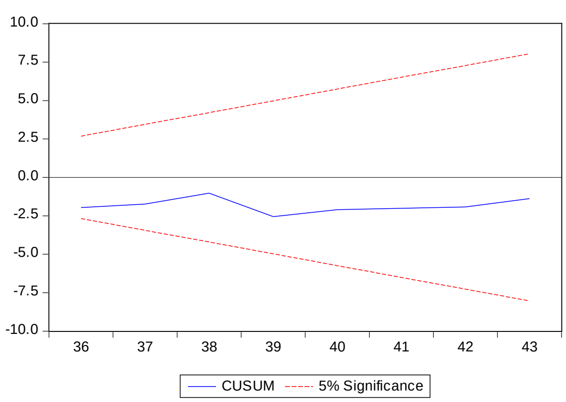


Figure 4.14: CUSUMSQ Test

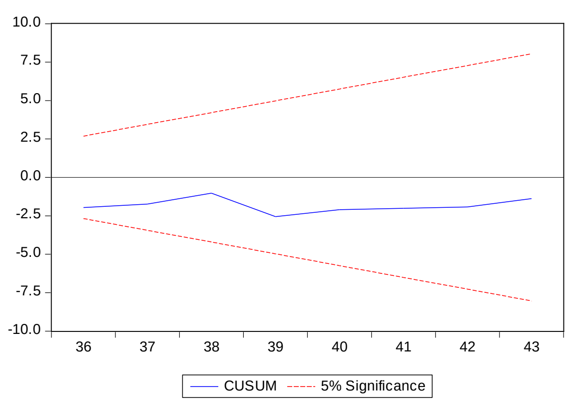


Figure 4.13 and 4.14 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

4.5.1.2. Short Run and Long Run Causality

The results of short run causality shows that there exists a bidirectional causality between aggregate electricity consumption and capital stock while unidirectional causality running from economic growth to aggregate electricity consumption. The results of the causality are similar to Chaudhry et al. (2012). Table 4.43 summarizes the short run and long run causality.

Table 4.43: Results of Short Run and Long Run Causality

Dep. Var	**Short Run Causality (Chi-Square Test)**					**Long Run Causality**
	Δln_y	**ln_k**	**Δln_lf**	**Δln_ms**	**ln_ec**	**ECT(-1)**
Δln_y	-	2.6030 (0.2721)	1.9458 (0.3780)	1.6137 (0.4463)	0.3056 (0.8583)	12.7596 (0.0004)
ln_k	1.2889 (0.5249)	-	0.8886 (0.6413)	0.3548 (0.8374)	33.1512 (0.0000)	-
Δln_lf	0.7518 (0.6867)	2.2060 (0.3319)	-	3.3777 (0.1847)	1.9238 (0.3822)	-
Δln_ms	2.8017 (0.2464)	2.8460 (0.2410)	0.0898 (0.9561)	-	2.8837 (0.2365)	-
ln_ec	16.0824 (0.0003)	6.7971 (0.0334)	3.5936 (0.1658)	1.3172 (0.5176)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

4.5.2. Results for Model of Disaggregate Electricity Consumption

4.5.2.1. Long Run and Short Run Dynamics

The results of bound test in table 4.45 shows that F-statistics falls above the upper bounds at 1% level of significance, which means that null hypothesis is rejected. So, this shows an evidence of strong cointegration. Results of the unrestricted ECM model and bound test are reported in table 4.44 and table 4.45 respectively.

Table 4.44: Unrestricted ECM Model Estimation

Dependent Variable: LnY Selected Model: ARDL (2, 3, 3, 3, 3, 3, 3)			
Variable	**Coefficient**	**Variable**	**Coefficient**
LnY(-1)	0.5797*** (0.1755)	**LnCoCE(-1)**	-0.0634* (0.0340)

LnY(-2)	-0.3954* (0.1952)	**LnCoCE(-2)**	0.0209 (0.0358)
LnK	-1.1351** (0.5259)	**LnCoCE(-3)**	-0.0790* (0.0385)
LnK(-1)	1.4175 (0.8169)	**LnICE**	0.0144 (0.0569)
LnK(-2)	-0.2137 (0.5459)	**LnICE(-1)**	0.2404*** (0.0737)
LnK(-3)	-0.0475 (0.0754)	**LnICE(-2)**	-0.1395* (0.0760)
LnLF	0.3992* (0.1997)	**LnICE(-3)**	0.2716*** (0.0685)
LnLF(-1)	0.3390* (0.1713)	**LnACE**	-0.0434 (0.0332)
LnLF(-2)	-0.3461 (0.2137)	**LnACE(-1)**	-0.0093 (0.0245)
LnLF(-3)	0.4379*** (0.1314)	**LnACE(-2)**	-0.0344 (0.0214)
LnMS	0.1632** (0.0575)	**LnACE(-3)**	-0.0290 (0.0212)
LnMS(-1)	0.0088 (0.0723)	**C**	17.9771*** (3.8740)
LnMS(-2)	-0.0273 (0.0601)	**R-squared**	0.9999
LnMS(-3)	-0.1040** (0.0479)	**F-statistics**	7798.287
LnCoCE	0.0367 (0.0317)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

Table 4.45: ARDL Bounds Test

Test Statistics	**Value**	**k**
F-statistics	6.833733	6
Critical Value Bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

The results of the diagnostic tests shows that the selected ARDL model is not suffering from serial correlation, heteroscedasticity and model specification error. Table 4.46 presents the results of the diagnostic tests.

Table 4.40: Diagnostic Tests

Breusch-Godfrey Serial Correlation LM Test			
F-statistics	2.807751	**Prob. F(2,11)**	0.1035
Obs*R-squared	13.51871	**Prob. Chi-Square(2)**	0.0012
Heteroscedasticity Test: Breusch-Pagan-Godfrey			

F-statistics	1.011623	**Prob. F(26,13)**	0.5120
Obs*R-squared	26.76919	**Prob. Chi-Square(26)**	0.4215
Ramsay RESET Test			
	Value	**Df**	**Prob.**
t-statistics	0.185225	12	0.8561
F-statistics	0.034308	(1, 12)	0.8561

Note: ARDL model is not suffering from serial correlation, heteroscedasticity and specification error.

The results of the long run dynamics obtained that capital stock has a positive but insignificant impact on economic growth. Labor force significantly and positively affects the real GDP. The coefficient of human capital is positive but insignificant. The parameter of electricity consumption in commercial sector has negative but insignificant influence on economic growth. The impact of electricity consumption in industry sector on economic growth is positive and significant, whereas electricity consumption in agriculture sector negatively affects the growth and it is significant. Results of long run coefficients are reported in table 4.47.

Table 4.47: Estimation of Long Run Dynamics

Variable	Coefficient
Cointeq = LN_Y - (0.0259*LN_K + 1.0174*LN_LF + 0.0500*LN_MS -0.1040*LN_COCE + 0.4743*LN_ICE -0.1422*LN_ACE + 22.0378)	
LnK	0.0259 (0.1202)
LnLF	1.0174*** (0.1214)
LnMS	0.0500 (0.0906)
LnCoEC	-0.1040 (0.0589)
LnIEC	0.4743*** (0.1352)
LnAEC	-0.1422** (0.0497)
C	22.0378*** (2.8983)

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively.*

The results of the short run dynamics in table 4.38 shows that the estimated coefficient of ECT is -0.94 which indicates that the deviation from the long-term equilibrium path is corrected by nearly 94 percent over the following year. Negative and significant coefficient of the ECT shows that economic growth, capital stock, labor force, human capital and electricity consumption in commercial, industry and agricultural sectors have long run relationship in Pakistan. Table 4.48 reports the results of short run dynamics.

Table 4.48: Estimation of Short Run Dynamics

Dependent Variable: ΔLnY			
Variable	**Coefficient**	**Variable**	**Coefficient**
Δ(LnY(-1))	0.4044** (0.1855)	**Δ(LnCoEC(-2))**	0.0769* (0.0382)
Δ(LnY(-2))	0.0738 (0.2060)	**Δ(LnCoEC(-3))**	0.0055 (0.0405)
LnK	-1.3236** (0.5384)	**Δ(LnIEC)**	0.0239 (0.0577)
LnK(-1)	1.2046 (0.9193)	**Δ(LnIEC(-1))**	-0.1650 (0.1235)
LnK(-2)	0.4427 (0.8104)	**Δ(LnIEC(-2))**	-0.2868*** (0.0653)
LnK(-3)	-0.3283 (0.2819)	**Δ(LnIEC(-3))**	-0.0125 (0.0957)
Δ(LnLF)	0.4725** (0.2120)	**Δ(LnAEC)**	-0.0392 (0.0269)
Δ(LnLF(-1))	-0.0822 (0.2144)	**Δ(LnAEC(-1))**	0.0608* (0.0302)
Δ(LnLF(-2))	-0.4695** (0.1584)	**Δ(LnAEC(-2))**	0.0459 (0.0263)
Δ(LnLF(-3))	-0.0823 (0.1797)	**Δ(LnAEC(-3))**	0.0089 (0.0187)
Δ(LnMS)	0.1440*** (0.0426)	**ECT(-1)**	-0.9385*** (0.2540)
Δ(LnMS(-1))	0.1447** (0.0652)	**C**	0.1382 (0.4073)
Δ(LnMS(-2))	0.1397* (0.0713)	**R-Squared**	0.9495
Δ(LnMS(-3))	0.0134 (0.0515)	**F- statistics**	7.6569
Δ(LnCoEC)	0.0320 (0.0244)	**Durbin- Watson stat**	2.2192
Δ(LnCoEC(-1))	0.0654 (0.0461)		

*Note: Standard errors are in parenthesis. ***, **, * shows significance at 1%, 5% and 10% respectively. Δ is the difference operator.*

Figure 4.15: CUSUM Test

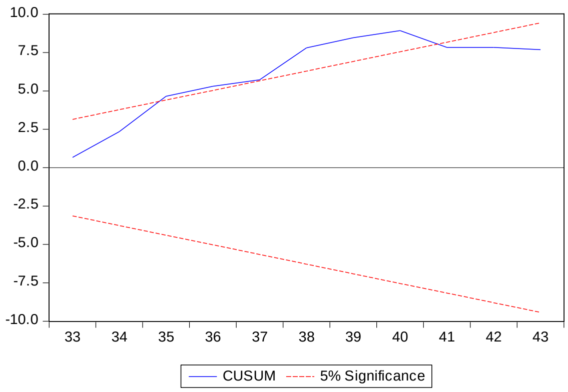


Figure 4.16: CUSUMSQ Test

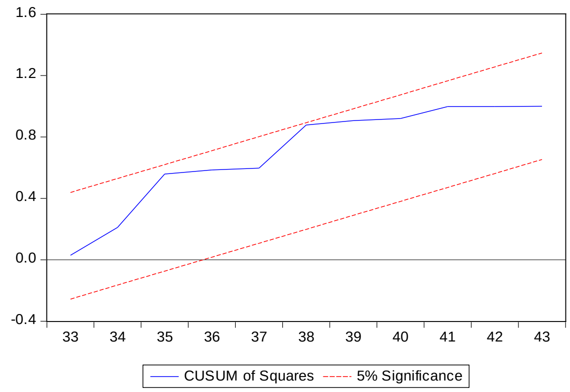


Figure 4.15 and 4.16 shows the CUSUM and CUSUMSQ tests respectively and from these graphs it is found that model is stable.

4.5.2.2. Short Run and Long Run Causality

The results in the short run in table 4.49 shows that causality running from labor force, human capital and electricity consumption in commercial sector to capital stock. Similarly, there also exists a unidirectional causality running from electricity consumption in commercial and industry sector to labor force, electricity consumption in commercial and agricultural sectors to human capital, economic growth to electricity consumption in industry sector and from economic growth, capital stock and labor force to electricity consumption in agricultural sector. Table 4.49 summarizes the short run and long run causality.

Table 4.49: Results of Short Run and Long Run Causality

Dep. Var	**Short Run Causality (Chi-Square Test)**							**Long Run Causality**
	Δln_y	**ln_k**	**Δln_lf**	**Δln_ms**	**Δln_coec**	**Δln_iec**	**Δln_aec**	**ECT(-1)**
Δln_y	-	2.9304 (0.2310)	3.7949 (0.1499)	0.9409 (0.6247)	1.6952 (0.4284)	3.6071 (0.1647)	1.2893 (0.5248)	13.6480 (0.0002)
ln_k	1.8815 (0.3903)	-	5.2721 (0.0716)	9.0332 (0.0109)	7.9923 (0.0184)	2.3335 (0.3114)	3.9319 (0.1400)	-
Δln_lf	0.8602 (0.6504)	0.1353 (0.9346)	-	2.6634 (0.2640)	7.4208 (0.0245)	4.8291 (0.0894)	2.1611 (0.3394)	-
Δln_ms	0.4344 (0.8048)	1.1193 (0.5714)	0.7138 (0.6998)	-	8.0977 (0.0174)	0.8114 (0.6665)	5.6800 (0.0584)	-
Δln_coec	3.7529 (0.1531)	1.3168 (0.5177)	1.3927 (0.4984)	0.2578 (0.8790)	-	0.2041 (0.9030)	0.3186 (0.8527)	-
Δln_iec	7.9350 (0.0189)	1.6213 (0.4446)	2.2319 (0.3276)	0.5900 (0.7445)	1.0911 (0.5795)	-	2.0401 (0.3606)	-
Δln_aec	8.1995 (0.0166)	8.1995 (0.0043)	4.7626 (0.0924)	3.8205 (0.1480)	1.008238 (0.6040)	1.8382 (0.3989)	-	-

Note: P values are in parenthesis. Δ is the difference operator.

5. Conclusion

The key objective of this study is to analyze the relationship between energy consumption at both aggregate and disaggregate levels in different sectors i.e. commercial, agriculture, industry, power and transport with economic growth in Pakistan. The general goals are to analyze the relationship between oil, coal, gas and electricity consumption and economic growth. This study has used time series data for the estimation. The data of Pakistan is used over the time period ranging from 1972 to 2014. The theoretical model used in this study is the neo-classical growth model which gives basic framework to analyze the relationship of aggregate and disaggregate oil, coal, gas and electricity consumption. The methodology used are ARDL and Granger causality test for short run and long run causality and models are verified with the help of diagnostic and stability tests.

The results of the study shows that there is a long run relationship between economic growth and aggregate and disaggregate energy consumption in different sectors of the economy. It is also found that there is no causality exists between aggregate and disaggregate oil consumption and economic growth, supporting the Neutral Hypothesis. In case of the coal consumption, their results supports the Conservation Hypothesis which means that there is unidirectional causality running from economic growth to aggregate and disaggregate coal consumption. While, in the case of gas consumption, there is unidirectional causality exists running from economic growth to aggregate and disaggregate gas consumption which also supports the Conservation Hypothesis. In the model of electricity consumption, Conservation Hypothesis also exists which means that unidirectional causality exists from economic growth to aggregate and disaggregate electricity consumption.

5.1. Policy Recommendations

In the light of above findings, the present study suggests the following recommendations:

- Government should enhance the economic growth by increasing the employment opportunities for labors in oil consumption in industry sector.
- In order to ensure energy supply, government should reduce the burden from coal and it should be converted to other indigenously available resources (hydro, gas or solar).
- Government should take reforms to reduce the consumption in commercial and agriculture sectors and transfer the units of electricity to the industries so that economic growth can be increased.

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Appendix A

Variables	Description	Sources
K	Capital (Gross fixed capital formation in constant LCU)	Pakistan Economic Survey
L	Labor Force (in millions)	Pakistan Economic Survey
Y	Economic Growth (Gross Domestic Product in constant terms)	Pakistan Economic Survey
MS	Total enrollment at middle school used as a proxy for human capital (in thousands)	Pakistan Economic Survey
OC	Total oil consumption (in tons)	Pakistan Economic Survey
IOC	Oil consumption in industry sector	Pakistan Economic Survey
AOC	Oil consumption in agriculture sector	Pakistan Economic Survey
TOC	Oil consumption in transport sector	Pakistan Economic Survey
POC	Oil consumption in power sector	Pakistan Economic Survey
CC	Total coal consumption (in metric tons)	Pakistan Economic Survey
PCC	Coal consumption in power sector	Pakistan Economic Survey
BKCC	Coal consumption in brick kilns sector	Pakistan Economic Survey
GC	Total gas consumption (mm cft)	Pakistan Economic Survey
CoGC	Gas consumption in commercial sector	Pakistan Economic Survey
CeGC	Gas consumption in cement sector	Pakistan Economic Survey
FGC	Gas consumption in fertilizer sector	Pakistan Economic Survey
PGC	Gas consumption in power sector	Pakistan Economic Survey
ICG	Gas consumption in industry sector	Pakistan Economic Survey
EC	Total electricity consumption (in Gwh)	Pakistan Economic Survey
CoEC	Electricity consumption in commercial sector	Pakistan Economic Survey
IEC	Electricity consumption in industrial sector	Pakistan Economic Survey
AEC	Electricity consumption in agricultural sector	Pakistan Economic Survey